FITZ WATER WHEEL CO.

THE

I-X-L STEEL OVERSHOOT WATER WHEEL

HANOVER, PA., U.S.A.

Dorothy Mitzler

..The I-X-L Steel..
Overshoot Water Wheel

Manufactured by

Fitz Water Wheel Company

R. T. Cooke

Bought of

Page 51

Hanover, Pa., U. S. A.

John Fitz, Manager.

Catalog Number 8

INTRODUCTORY

WE HAVE ENDEAVORED, in this Eighth Edition of our Catalog, to describe a few of the points which make the I-X-L Steel Overshoot Water Wheel so far superior to any other form of hydraulic motor. We have also tried to make a booklet which will be of practical use to every present or prospective user of water power. The tables, rules, etc., in this book have been subjected to careful revision and may be depended on as correct.

When we first began to devote our exclusive attention to the manufacture of steel overshoot water wheels, we had to struggle against an almost overwhelming mass of prejudice and misrepresentation. The old-style wood overshot, clumsy and lop-sided, leaky and ice-bound, had fallen into well deserved disrepute. The turbine craze was in full swing and it was the fashion to speak of the overshot as out-of-date.

Since the advent of the I-X-L the overshoot has been restored to favor and it is acknowledged on all hands that it is unrivaled for efficiency and economy of water, "when properly constructed," which is only another way of saying "when constructed by the Fitz Water Wheel Co." This change in attitude is due solely to the remarkable work of the I-X-L Steel Overshoot, for it is the only well-built and properly constructed wheel of this type on the market. It has so far excelled the turbines and other wheels in numberless tests that it has compelled its own recognition as the best and most economical wheel in the market and has redeemed the reputation of the overshot type from the disgrace into which it had fallen through the mistakes of the wood wheel builders.

This company is the successor of the Hanover Foundry & Machine Shops, established by Mr. Samuel Fitz, in 1840, at Hanover, Pa., and the Tuscarora Iron Works, of Martinsburg, W. Va., which was established by Mr. Fitz in 1850. The business was carried on under the name of the I-X-L Steel Overshoot Water Wheel Co., until July 15th, 1902, when the name was changed to Fitz Water Wheel Co., for the sake of brevity.

For more than forty years we have built iron and steel wheels in our shops. For many years the number was limited owing to expensive methods of manufacture. The past ten years, however, have been busy ones. The great increase in demand has been caused principally by our improved methods of construction and manufacture, but also by the close

competition in the milling business, which has forced millers to look for a wheel which will do their work in the most economical manner. That the I-X-L is the only wheel that can fill this want, is no longer disputed.

The best evidence of a firm's reputation and reliability is the confidence placed in them by the people who know them best. With a record of nearly three-quarters of a century of fair and square dealing behind us we have no trouble in obtaining practically all the water wheel contracts in our own and surrounding counties.

The manufacture of overshoot water wheels is our specialty. We are continually, and at great expense, introducing in our shops the latest and best tools adapted to our work. Many of our heaviest machines have been designed and built exclusively for us. We use the most skilled and intelligent labor we can procure. No pains are spared to improve our product or lessen the cost of manufacture wherever possible. We have recently added to our equipment a full line of pneumatic tools for riveting, chipping, drilling, etc., thus making compressed air do much of the work formerly done by hand. Our new brick shops, completed in the fall of 1905, are more than twice the size of our old plant, and are fully equipped throughout with electric motors and new tools, so that we are now enabled to handle our work with greater speed and economy than ever before.

Situated, as we are, in the heart of the world's coal and iron supply; enjoying unexcelled shipping facilities via the great Pennsylvania and Wabash systems, we buy our material as cheap as anyone and obtain the lowest freight rates. The basis of our prices is the cost of production, and we give our customers the benefit of our superior advantages.

In closing we would call your attention to our gearing. We have a large line of patterns of the latest and most approved design. We have made a study of gear teeth and have produced a tooth that will run with very little friction or jar. We have a force of skilled and experienced pattern makers constantly at work and we are prepared to make patterns and estimates for anything in our line.

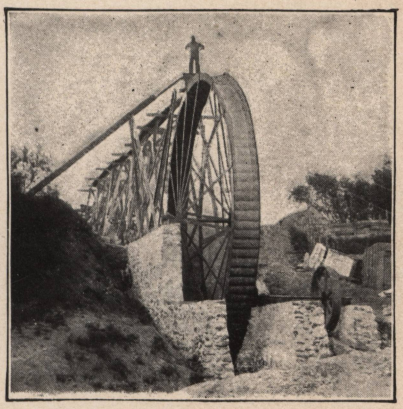
TERMS AND PRICES

THERE BEING so many sizes and conditions under which these wheels must work, it is impossible to have a regular price list for them. Each wheel is built to suit its own particular location and each job is estimated on separately. Give us the information asked for on next to last page of catalog and we will be enabled to quote you on just what you need for your location.

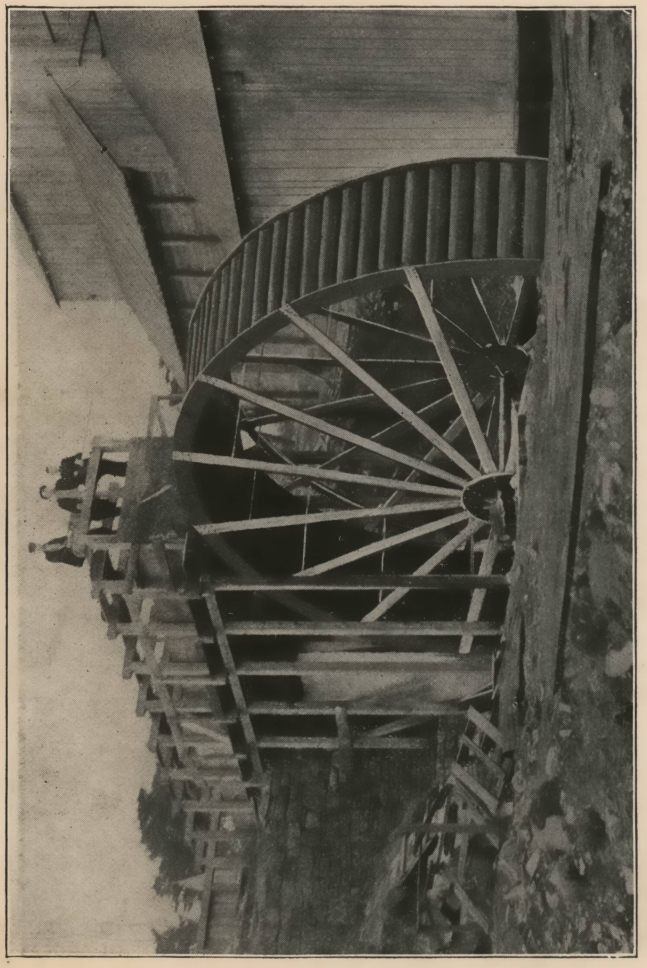
All prices quoted are on a basis of net cash. However, when good security is given, and our customers desire it, we can accept half or one-third cash and balance in 3, 6, 9 or 12 months negotiable notes bearing interest at 6 per cent., this being the same as cash to us for we can have them discounted at face value when necessary. Of course this applies only to customers living within the United States and secured by good endorsers. To all others, our terms are strictly net cash on delivery at New York.

Particular attention is given to export orders. Correspondence will be carried on in French, German or Spanish if desired by our customers. Our wheels can be packed in small sections for muleback transportation at slight extra cost. All parts are plainly marked or numbered and are very easy to put together, having been previously fitted together in our shops.

If desired we will furnish free with each wheel a blue print drawing for installation, with necessary tools and full instructions for putting together.



36 FT. BY 3 FT. I-X-L WHEEL DRIVEN BY ARTESIAN WELL IN SOUTH DAKOTA.



30 FT. DIAM. BY 6 FT. FACE I-X-L STEEL OVERSHOOT WATER WHEEL, DRIVING PLANT OF HOWARD BRICK, CO., HOWARD, PA. THIS WHEEL IS EQUIPPED WITH I-X-L GOVERNOR.

DEVELOPMENT OF WATER POWER

OF LATE YEARS water power has assumed a commercial value of great importance. With increasing costs of fuel and labor, all shrewd men are beginning to realize that every water power is a potential source of income. The larger the power, the more it is worth of course, but any power is capable of earning money if properly developed. Its earning capacity is regulated by the cost of producing a similar amount of steam power and varies considerably with different localities, but is nearly always sufficient to pay a very high interest on the capital invested.

Wherever a stream flows from a higher to a lower level, it is possible to develop power by using a water wheel of some kind. The amount of power it is possible to obtain depends upon the amount of water and upon the head or fall which can be secured.

In every system of water power development there exist three principal parts, viz :—

(1) A supply channel or head race, carrying the water from the highest accessible level to the point at which the water wheel is placed. This may be constructed of earth, wood or iron. The latter is preferable as it wastes no water and requires no attention after once being laid. It is highly desirable to have a dam or storage reservoir in connection with the head race so that water may be stored up over night or when not running.

(2) Leading from the water wheel there is a tail race to carry off the water at the lowest possible level after it has done its work. This should always be plenty wide enough and laid at a slight slope to enable the water to escape freely without choking the wheel or other motor used.

(3) The motor or water wheel itself by which the power is derived from the falling water. The utmost care should be exercised in its selection, for most wheels waste from a third to half the power they should develop. Since the success of an enterprise of this sort depends upon the amount of and the reliability of, the power developed it follows that the water wheel should be one that will develop all the power possible for the situation. The water wheel represents but a fraction of the cost of the dam, raceway, etc., so it certainly does not pay to waste a large part of the power for the sake of saving a few dollars on a cheap inefficient wheel.

17 FT. DIAM. BY 5 FT. FACE I-X-L STEEL OVERSHOOT WATER WHEEL DRIVING PLANT OF WILLOW GROVE MILLING CO., LURAY, VA.

By repeated tests the I-X-L has shown that it will develop at least 33⅓ percent. more power than the best turbine made using the same amount of water. We are well aware that some turbine builders claim from 80 to 85 percent. efffciency for their wheels, and pretend that this is proven by their records in the testing flumes. It is true that a few turbines have given a little over 80 percent. efficiency when tested at full gate, but it must be remembered that these were special wheels, built regardless of expense and working under the most favorable conditions known. The accuracy and practical value of these tests may be seen from the fact that no two wheels of the same make and size would give the same efficiency, and even the same wheel when tested at different times would vary considerably in efficiency. It is well known that conditions are much less favorable to turbines in actual use than to those in the testing flume, where everything is perfectly arranged, and also, that when you buy a turbine from any builder you don't get near as good a wheel as the one he builds expressly to be tested. We know it to be a fact that there is no turbine built today that will develop over 70 percent. efficiency in actual use, and the great majority fall much below this.

But it is not enough to merely consider the efficiency of a wheel with a full head of water. It is just as important to know how a wheel will act with a diminished head or scanty supply of water. No stream of water is of the same size at all seasons and a wheel that is not adaptable to varying conditions is useless a large part of the year. This is the point where all turbines, despite the claims of their makers, fail absolutely, for unless they are run at full gate, or nearly so, they will do very little work. The steel overshoot is a model wheel in this regard, as in every other respect, for it will run just as economically at one-fourth gate as at full gate, while when water is plentiful, it can be crowded far beyond its normal capacity.

Besides these most important considerations of high efficiency and adaptability to varying conditions, there are five other points that an ideal wheel should possess, viz :—

(1) Freedom from clogging and freezing.
(2) Tight gate.
(3) Perfect balance.
(4) Durability.
(5) Ability to do good work in back water.

These points are only to be found in the I-X-L Steel Overshoot Water Wheel. The large buckets cannot possibly become clogged with leaves, sticks, or anything else, as all turbines do, for whatever goes through the gate will pass over the wheel freely. Ice, which causes so much trouble with wood wheels and turbines, has little or no effect upon the steel overshoot. It cannot form on the wheel as long as it is in motion, for the thin steel readily acquires the temperature of the water passing over it and remains above the freezing point. Even should any ice form on the wheel while

standing, a few strokes with a hammer will cause the wheel to ring like a bell and will shiver the ice all off, for there is nothing for it to cling to.

Our improved iron gate, furnished with all our wheels, is simple in construction and shuts the water off perfectly. No turbine gate or wood gate ever constructed can approach it for durability and economy of water.

Our wheel is built in perfect balance as every part is exactly alike. It cannot become heavy-sided by absorbing water or drying out. It gives a smooth regular motion well suited to roller mill machinery, pumping plants, electric plants, etc.

Our wheel excels all others for durability. We can show you wheels in operation that have been running since 1850 with little or no expense for repairs. There is nothing about the steel wheel to break or get out of order. All bearings can be easily gotten at to oil and it is no trouble to look after them occasionally.

Back water, which will soon stop either a turbine or a wood overshot, has very little effect on the I-X-L. We always calculate our wheels to accommodate from one-fourth to one-half more water than the normal volume of the streams which drive them. Consequently at flood periods more water can be used on the wheel, thus overcoming the loss of head in backwater. Owing to the unique design of our buckets there is no loss of power by friction or sucking up water when wading.

We have devoted our attention to water wheel machinery for a good many years and during that time have built in our shops several types of turbines, pitch-backs, breast-wheels, undershots, and Poncelot Wheels. We are familiar with the locations to which each style of wheel is adapted and have learned their limitations by practical experience. If you will give us the information asked for on the next to last page of this booklet we will be glad to tell you what can be done and what is the best type of wheel for you to use. Not every site is adapted for an I-X-L Steel Overshoot, but within its own field it is without a rival worthy of the name. For any fall from 8 ft. to 50 ft. and for any quantity of water not exceeding 2500 cu. ft. per minute, for a single wheel, there is only one wheel to be considered if you want satisfactory results and that is the I-X-L Steel Overshoot.

DESCRIPTION OF THE I-X-L

THE I-X-L Steel Overshoot Water Wheel belongs to the class known as "gravity wheels." The water acts directly by its weight loading one side of the wheel and causing it to turn. The size of the wheel depends largely on the situation but we generally make them about two feet less in diameter than the available head. The force of the water above the wheel is not lost but acts by its impulse upon the wheel just as in a turbine or impulse wheel. The water strikes the wheel one bucket back of the centre in such a manner as to utilize the full force of its percussive power, and is retained by the peculiar shaped buckets until it almost reachesthe centre again at the bottom. The housings of the wheel, instead of coming flush with the buckets as in a wood wheel, are extended so as to prevent any water splashing over the sides. Thus not a drop of water is wasted and the water is discharged in the tail race with all its power extracted. Compare the calm stream flowing from the I-X-L with the rushing torrent discharged by the turbine and you will see one of our strongest points. No turbine gets more than 70 per cent. of the energy out of the water, and the momentum of the tail race represents a considerable part of the remaining thirty per cent.

The object of all wheels is to utilize the weight of the falling water and develop power thereby. The overshoot does this in the most direct manner and therefore with the least loss. The turbines and other wheels aim to develop their power in an indirect manner by reaction or impulse caused by pressure. To give even moderately good results they must be geared to run at a certain speed, under a certain pressure and using a certain amount of water. On a variable stream, such as most are, these conditions are constantly changing, thus causing great loss of efficiency to the turbine. Since the overshoot depends mainly on the positive weight of the water and only in a small degree on impulse, it can run fast or slow, with high head or low head, at full gate or fractional gate, with equally high efficiency, and developing power in exact proportion to the amount of water used.

Then again the perfect balance and absence of friction in the bearings of the I-X-L are such that a little child can turn our largest wheel with one hand. Thus we are enabled to transmit undiminished to the jack shaft the energy we have extracted from the water.

The I-X-L Steel Overshoot will develop at least one-third more power than any turbine using the same amount of water, or one-fourth more than

the best wood wheel made. This has been tested and proved so often that it scarcely needs any further demonstration. We can refer you to many mills where we have installed the I-X-L side by side with the wood wheel or turbine and working under precisely the same conditions and in every case the I-X-L has more than fulfilled our claims. In any number of cases we have doubled the power over the turbines and "best wood wheels in the State," so we are very conservative in the foregoing figures.

Because of their unrivalled efficiency, adaptability and power, economy of water, steady and regular motion, excellence of construction, and all round superiority, our wheels are rapidly displacing all others for flour and feed mills, pumping stations, machine shops and factories of all kinds.

CONSTRUCTION.

Our I-X-L Steel Overshoot Water Wheel has been a study for years and is built on scientific principles by expert and experienced mechanics with special tools. We use the finest hammered steel for the shaft, with bearings resting on cast iron bases or pedestals which are self-adjusting. We now use improved roller-bearing or chain-oiling boxes, which reduce the friction and add to the power.

The center flanges or hubs are made of cast iron with dove-tailed sockets to receive the arms, and are keyed on the shaft with two keys each. To these flanges are bolted the arms which are of flat bar steel and cast iron.

The rim is built in sections with soleing, buckets and housings all firmly and closely riveted together by compressed air. It is shipped knocked down, in eight or more pieces and when assembled at the mill is riveted together and securely fastened to the arms with heavy bolts.

The buckets are made with a peculiar curved formation so as to retain the water until the power is totally exhausted. The entire rim is made of the best flanged steel, highly polished to afford a smooth surface impervious to rust and well coated with oxide paint. We use the best rivets, bolts, and other parts that we can secure, and with experienced workmen construct a wheel that will last a life time.

These wheels are all fitted together in the shops. Every part is plainly marked and numbered, so that there can be no difficulty in erecting. We will furnish drawing for setting and full instructions and tools so that the purchaser can erect the wheel himself without trouble. Or if desired we will contract for the wheel delivered and put in, doing everything but the stone or foundation work.

34 FT. DIAM. BY 3½ FT. FACE I-X-L STEEL OVERSHOOT WATER WHEEL, DRIVING FLOUR MILL BY MANILA ROPE. THE WHEEL WAS LOCATED ABOUT 100 FT. FROM THE MILL TO SECURE THE FALL.

COMPARISON WITH TURBINES

WITH a large stream of clear water which never varies in volume, and a good fall, well made turbines will work very satisfactorily. It is true that their efficiency is always over-rated—very few of them in practical use giving over 50 or 60 per cent. of the power they should develop—but of course where there is an abundance of water it is not necessary to be economical. But on a light stream, or wherever it is desirable to get the full power from the water, they are failures. The capacity of a turbine is unchangeable. If you have more water than you need, it is wasted. If less, it will hardly turn the wheel. The reverse is the rule of the I-X-L, as its adaptability to varying conditions is one of its strongest points. When water is scarce it will develop the full percentage of power, while with an abundance of water the wheel can be crowded far beyond its normal capacity.

A turbine depends for its power upon the reaction or impulse of the water discharged under pressure of the working head. The pressure is due to the weight of the water and is proportional to the working head of water over the wheel. The higher the head the greater the pressure, and hence the velocity of the water discharged. The wheel must run at a certain proportionate velocity, the buckets must be curved at a certain angle, and the water must be discharged in a certain volume in order to do good work. All these points must be right in order to obtain even 50 to 70 per cent efficiency, and they are fixed by the volume of the stream to be used and the amount of fall to be secured. Most streams are constantly varying in volume and it is impossible to supply the wheel with the same amount of water or to keep up the same head, so the conditions are seldom favorable for a turbine to reach its maximum efficiency. It cannot adapt itself to the changed conditions of diminished supply or lowered head, consequently in dry weather, when economy of water is most necessary, the turbine is most wasteful, and will do practically no work at all. Even under the most favorable conditions much power is wasted by friction of water in the flume and case, and friction on the step working at high speed under heavy pressure. Of course it is impossible to shape the buckets so perfectly as to divert all the energy from the water delivered to them, so that a large part of the power always escapes to the tail race.

Of course we are aware that all turbine manufacturers table their wheels at 80 per cent. efficiency or higher and that each claims that he alone has

solved the impossible problem of making a turbine to work equally well at partial gate as at full gate. These foolish claims are a result of conditions established among the trade many years ago. Since it is the universal custom, the turbine man who did not make such claims would not get any hearing for his wheel. The customer has usually no means of testing his wheel and does not realize the outrageous discrepancy between the power promised by the turbine men, and the results actually attained.

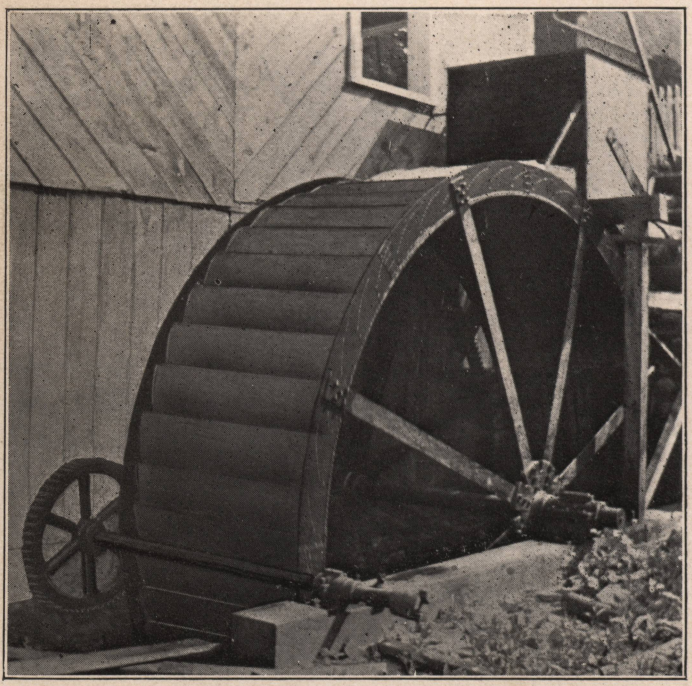
The I-X-L Steel Overshoot Water Wheel will give at least a third more power than the best turbine using the same amount of water, because it develops its power by utilizing the weight of the water in the simplest and most direct manner possible, instead of indirectly through impulse or reaction, as in the turbine. The water is received from the forebay in such a manner as to utilize as much as possible of the impulse due to the head in the forebay, and is retained by the correctly curved, water-tight buckets until it reaches the centre again at the bottom, where it is discharged in a calm stream with all the energy extracted. There is no occasion for loss of power in this process ; no splashing, no leaking or spilling too soon. If half the normal quantity of water is used on the wheel it will develop half the power, or one-fourth the power with one-fourth the water, thus showing that its efficiency is unimpaired by the changed conditions. No power is lost by friction for a child can turn our largest wheel with one hand.

On an ordinary stream, in the course of a year's run, the I-X-L will do nearly twice as much work as a turbine. It will give a third more power than the turbine at full gate, and at partial gate it will give two to three times the power, depending upon the quantity of water used.

A great deal of trouble is experienced by turbine users in hilly or sandy localities where the frequent floods and freshets wash down great quantities of sand and grit, which are very hard on their wheels. The leaves, sticks and other trash which get into the buckets and choke up the narrow vents are also a constant annoyance and frequently stop the wheels. The turbine flume, if built of wood, requires constant attention and repairs. The gates are invariably leaky after a few months use and waste a great deal of water. The complicated construction of some turbines make them particularly apt to get out of order, but they all give more or less annoyance in this regard.

None of these troubles have any effect whatever upon the I-X-L Steel Overshoot. There is nothing about the I-X-L to break or get out of order. Every part is exposed to view and easily accessible, but the only attention it requires is to oil the bearings occasionally. The gate is as near perfection as possible for anything which has to work in water, and owing to its simple construction will remain for years just as tight as the day it was put in. The large buckets cannot possibly choke up no matter how dirty the stream is, for anything that will pass through the gate will pass over the wheel without the slightest injury.

The condensed experience of thousands of water power owners shows that if you have more water at all seasons of the year than you can use, so that economy of water is no object to you, then you can use a turbine satisfactorily, provided you are not greatly troubled with sand or trash in your stream. But if you want to get all out of your water power that there is in it; to develop the highest efficiency at all times, no matter how low the water is; if you want durability and freedom from repairs; economy and satisfactory results, then the I-X-L Steel Overshoot Water Wheel is the only wheel on the market worthy of your consideration.



16 ft. diameter by 5 ft. face I-X-L Steel Overshoot Water Wheel, controlled by our I-X-L Governor and driving chopping mill; machine shop and electric light plant for P. McManus, Pomeroy, Pa.

This is a snap-shot taken while wheel was running at full speed. Note the absence of the leaking, and splashing which can't be overcome in the wasteful wood wheel.

COMPARISON WITH WOOD WHEELS

THE trouble with the wood overshots is easily explained. In the first place they are built of a material which is not fit to be used for water wheel construction, and in the second place they are usually built by men who know little or nothing of hydraulics.

The overshot type of water wheel has long been known, but until the time when we began their construction, almost all overshots were built entirely of wood, except for gudgeons. That is why all the old engineering text books rate the overshot at about 60 to 75 per cent. efficiency which is a good percentage for wood wheels to-day.

While it is true that a well-built wood wheel will give somewhat better results than a turbine on a light stream, yet it wastes a great deal of power in many ways, and its use is very annoying. Standing idle for even one day the wood wheel becomes heavy on one side. The wheel is then out of balance and its irregular and unsteady motion is very hard on all machinery in the mill it operates. The constant swelling and drying of the wood, soon makes all parts get loose, and the wheel requires frequent repairs. These difficulties cannot be overcome for they are inherent in the nature of the material used in its construction. The wood wheel can always be depended on to break down when the mill is busiest or when the weather is coldest, and the time and money lost by such occurrences would represent a neat sum of money to the owner of the mill every year.

In regard to power and economy of water, the wood wheel cannot be compared to the I-X-L Steel Overshoot. The buckets are shallow and straight, and they begin to discharge their water when about half way down the wheel, thus wasting a good deal of power. It is necessary to waste some of the head on a wood wheel, for the wheel must be kept high out of back water, and the chute has to be slanted to get the water into the buckets. The weight of a wood wheel, well soaked with water, is enormous, and the friction on the bearings is considerable. The wheel cannot be made watertight, and the leaking and splashing represent a great deal of wasted energy, besides causing the building in which it is situated to rot. Aside from these wastes of power which cannot be avoided, it is well known that the wood wheel is usually geared wrong, and speeded improperly, which detracts still more from its already low efficiency.

Their supposed cheapness is about the only argument to be made in favor of the wood wheel. No one, however, who has given the matter any

consideration will be misled by this. Most owners have invested a considerable sum of money in developing their water powers and it is one of their most valuable assets. The cost of the water wheel represents but a fraction of this sum, but the earning power of the whole investment depends upon the work done by the wheel. A wheel that wastes from one-fourth to to one-half the power cannot be regarded as a cheap wheel, no matter if it could be built for nothing. A water power plant cannot afford to stand idle when water is scarce, for a large part of the expenses go on just the same whether the plant is running or not. The steel wheel will give at least one-fourth more power than the best wood wheel made, and this means increased capacity and increased profits, and increased value for the entire plant.

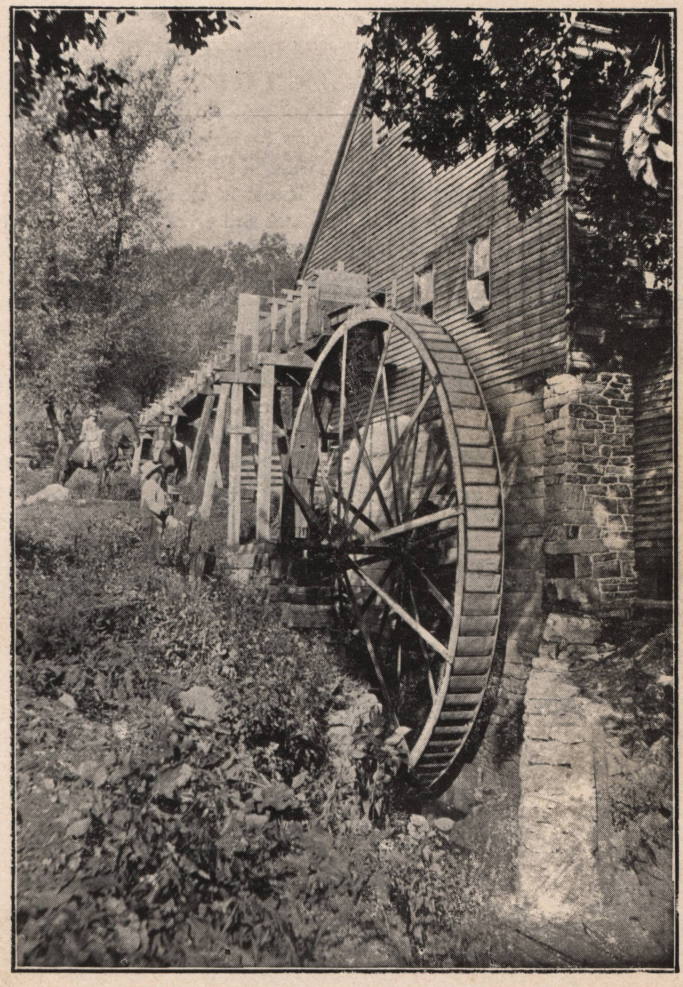
The life of a wood wheel is short, not much over ten years as a rule. We have been building steel wheels for more than forty years and the first wheel we built is still running at our old plant at Martinsburg, W. Va. The polished surface of our buckets resist rust, until the action of the running water puts a coat of sediment or slime on them which protects them still better.

Back-water, so fatal to a wood wheel, has very little effect on an I-X-L. Our buckets glide through the water without friction and are provided with air holes to prevent them from sucking up water, as a wood wheel does. One of our 17 ft. wheels driving the pumping plant of the Hanover & McSherrystown Water Co., near our town, frequently wades in six feet of back-water without affecting the power. Water is plentiful at such times and more can be used on the wheel to overcome the loss of head.

In cold weather ice gathers on the arms and shaft of a wood wheel, putting it to a terrible strain and often causing it to stop running. Every one who has attempted to cut ice from a wood wheel knows what a difficult and dangerous job it is, and how frequently it must be done in a severe winter. Ice does not trouble a steel wheel for reasons already explained. We have them running through the coldest weather in all our northern States and Canada, and their owners experience no trouble in this regard. Its superiority on this point alone would make the steel wheel worth more than the difference in cost.

The wood wheels are heavy and clumsy; troublesome to keep in repair, and are very wasteful of time, power, water and money. No progressive man will instal one of these out-of-date makeshifts in his factory today, for their use is a standing advertisement of crude methods and false economy.

The I-X-L Steel Overshoot is far superior to the wood wheel in every detail; will give at least 25 per cent. more power using the same amount of water; and is always in perfect balance and perfect order. It will outlast a number of wood wheels and will give far better satisfaction every day of its life.



26 FT. DIAMETER BY 2 FT. I-X-L STEEL OVERSHOOT AT MILL OF E. A. ANDRICK, TIMBERVILLE, VA.

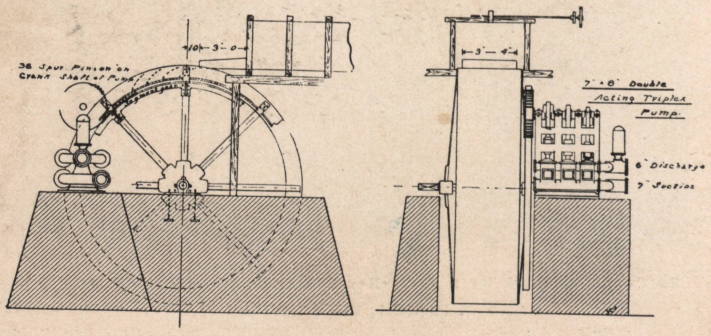
This wheel makes one barrel of flour per hour with gate 18 in. wide raised 1¾ in. Head of water in forebay=26 in.

PUMPING AND ELECTRIC PLANTS

THE I-X-L Steel Overshoot Water Wheel is especially well adapted for driving pumping plants for towns and private residences. Its great strength and adaptability to varying conditions of water supply and pressure enable it to operate a pumping plant with little or no attention. There is nothing about an I-X-L to break or get out of order. Sticks, stones, etc., do not trouble it, for anything that will go through the gate will pass over the buckets without damage.

No matter how low the water gets, the I-X-L will continue to perform its work surely and steadily for we gear direct to the crank shaft of the pump and the water exerts such a leverage that very little is required to keep the pump going. Many plants which we have installed have been in operation for years, requiring no looking after, except for daily oiling. A better or more economical way of operating a pumping plant can hardly be imagined.

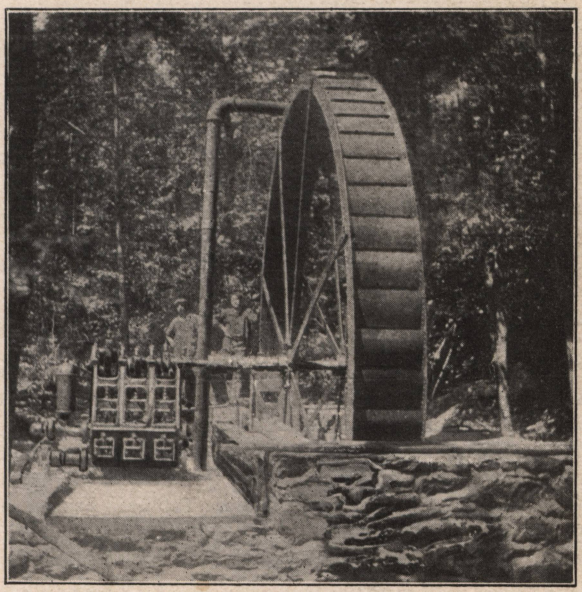
Reliability and efficiency are the two great considerations in the selection of a water wheel to drive a pumping plant. The I-X-L is in a class by itself as regards both these points; and its great durability, perfect balance, and careful construction make it an ideal wheel for this work. For one



I-X-L WHEEL AND TRIPLEX PUMP FOR PUMPING WATER TO HIGH ELEVATIONS.

group of capitalists owning water works in a number of places, we have installed six wheels within a few years in as many different towns. This is pretty good evidence that our wheels are fully up to our claims.

We build wheels as small as two feet in diameter to drive small pumping and electric light plants for private residences. A wheel 6 ft. diameter by 2 ft. face is capable of furnishing twenty to thirty lights at a time. A plant of this sort is inexpensive to instal and costs practically nothing to maintain. We can furnish the complete outfit if desired.



THE I-X-L DRIVING A TRIPLEX PUMP.

This illustration represents an I-X-L Steel Overshoot Water Wheel 20 feet diameter by 1½ feet face at Mt. Pocono, Pa. This wheel is supplied with water by a 6 in. pipe, which is never entirely full. The water wheel shaft is coupled direct to the crank shaft of a 5½ x 8 in. triplex pump, forcing 25 gallons of water per minute to an elevation of 400 ft. to the reservoir of the Montanesca Hotel. A turbine installed here two years previously, proved a complete failure, while gasoline engines were exceedingly expensive.

PUMPING PLANT INFORMATION

O compute the horse power necessary to raise water to any given height: Multiply the gallons per minute by 8.33. Multiply this product by the feet lift. The result is foot pounds. Divide by 33000 to reduce to horse power per minute. (A liberal allowance should be made for friction, etc.)

To compute the capacity of pumping engines, multiply the area of the water piston, in inches, by the distance it travels, in inches, in a given time. The product divided by 231 gives number of gallons in time named.

To find quantity of water elevated in one minute, running at 100 ft. of piston travel per minute: square the diameter of water cylinder and multiply by 4. Example—If the capacity of a 5 inch cylinder is desired, the square of the diameter (5 inches) is 25, which multiplied by 4 gives 100, which is gallons per minute (approximately.)

To find the diameter of a pump cylinder to move a given quantity of water per minute (100 ft. of piston travel being the speed) divide the number of gallons by 4, then extract the square root which will be the required diameter in inches.

To find the velocity in ft. per minute necessary to discharge a given volume of water in a given time, multiply the number of cubic feet of water by 144, and divide the product by the area of the pipe in inches.

To find the area of a required pipe, the volume and velocity of water being given, multiply the number of cubic feet of water by 144 and divide the product by the velocity in feet per minute. The area being found it is easy to get the diameter of pipe necessary.

Capacity of pipes: A pipe one yard long holds as many pounds of water as the square of its diameter in inches. Thus a 6 inch pipe holds 36 pounds of water in each yard of length.

Doubling the diameter of a pipe increases its capacity four times. Friction of liquids in pipes increases as the square of the velocity.

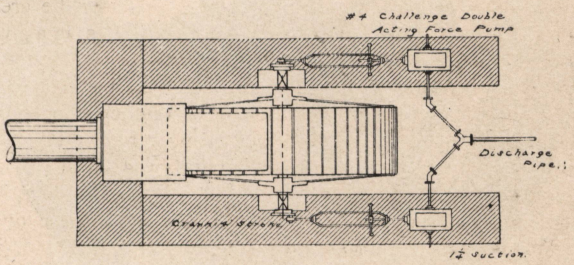
The mean pressure of the atmosphere at tide level is usually estimated at 14.7 lbs. per square inch, so that with a perfect vacuum it will sustain a column of mercury 29.9 inches, or column of water 33.9 feet high. In ordinary practice we recommend pumps be placed not over 20 feet above water supply, and even nearer, where possible.

To find the capacity of any single acting cylinder, square the diameter (in inches) of the cylinder, multiply this by .7854, and the result (which is

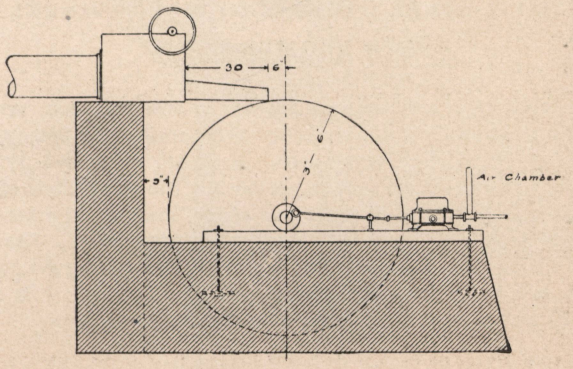
the area of the circle of cylinder) by the length of stroke in inches. This gives the capacity in cubic inches per stroke. Multiply this by the number of strokes per minute and divide the product by 231, (the number of cubic inches in a gallon of water.) The result will be the capacity of gallons of water the cylinder will discharge per minute.

A two-cylinder or double-acting cylinder has double the capacity of a single-acting cylinder.

To find the pressure in pounds per square inch of a column of water, multiply the height of the column in feet by .434. Approximately, we say that every foot elevation is equal to ½ lb. pressure per square inch ; this allows for ordinary friction.



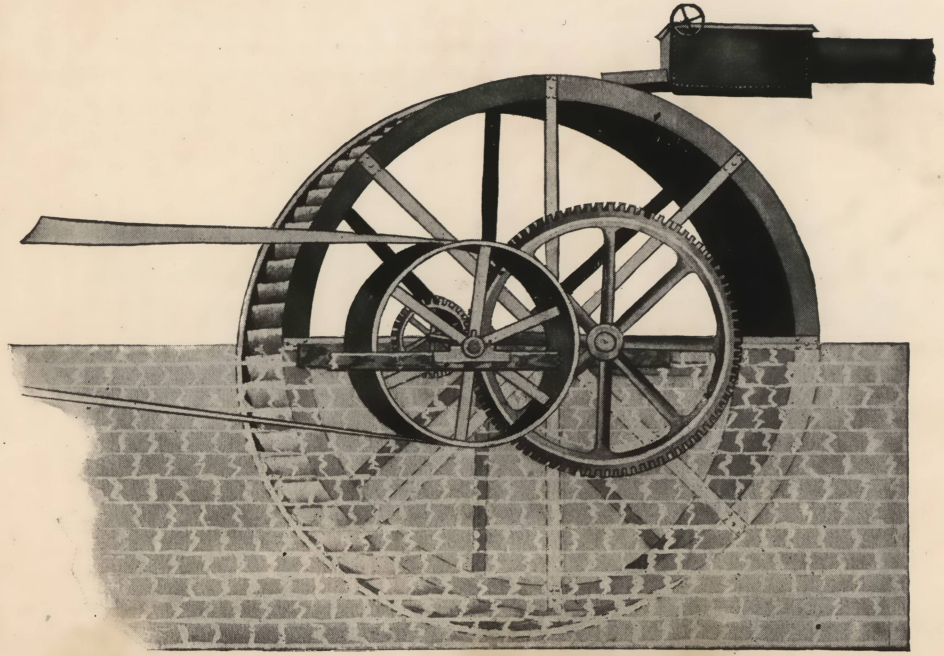
IXL STEEL OVERSHOOT WATER WHEEL AND SMALL PUMPING PLANT FOR ELEVATIONS UP TO 150 FEET



I-X-L STEEL OVERSHOOT WATER WHEEL WITH SEGMENT GEAR

The segments of gear are perfectly true to size and pitch, very strong and well proportioned. They are bolted to the arms of the water wheel with long lugs and six or more heavy bolts. Each nut is secured by a patent spring nut-lock and cannot work or get loose. The entire circle of the segments is carefully fitted together in our shops, clamped to arms of water wheel, and drilled by special drills before being taken apart. The segment gear as we make it is very strong and rigid, transmitting the power with very little loss by friction and securing speed very quickly. It is our most popular as well as most economical style of gearing.

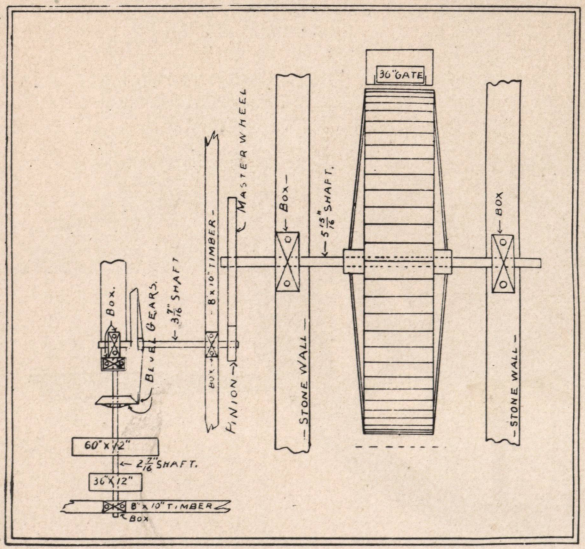
THE I-X-L WITH MASTER WHEEL GEARING.



This style of gearing is suitable to many locations, especially where the water wheel is not much over 18 feet diameter. The master wheel is generally made in two pieces and is keyed to the water wheel shaft inside the mill being entirely separate from the water wheel itself. The master wheel may be either a spur gear, as shown in the illustration, or a bevel gear. For many situations this is an ideal method of gearing.

A

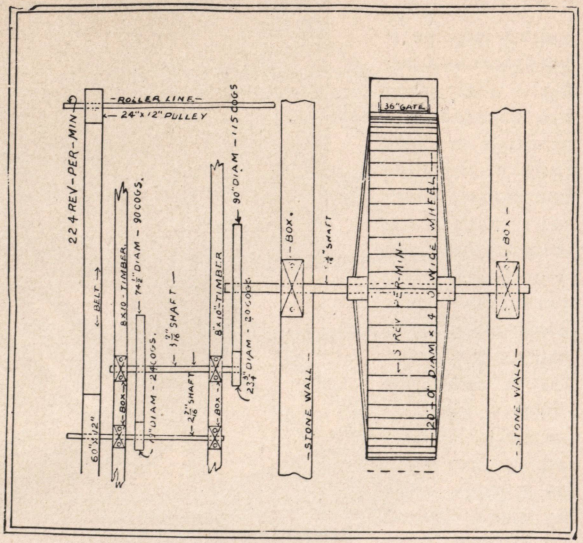
The I-X-L With Spur Master Wheel to Drive Buhrs.



This is one of our popular plants for driving old mills where a wood wheel was once used. The old gear wheel can be used again by a unique method we have of filling up the eye to suit our steel shaft. An old bevel gear can be used the same way.

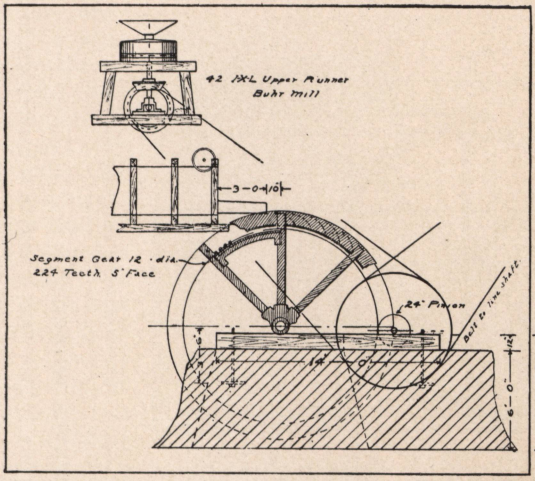
B

The I-X-L with Spur Master Wheel to Drive Roller Mill.



Another method of utilizing the old wood wheel gearing to drive mill by belt. This plan is often used for old mills, when the old gearing is good, and it makes the expense less.

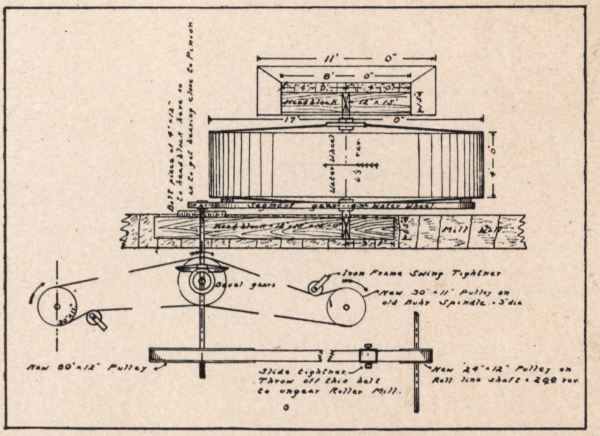
C



I-X-L Water Wheel and Segment Gear, to drive Portable Buhr Mill.

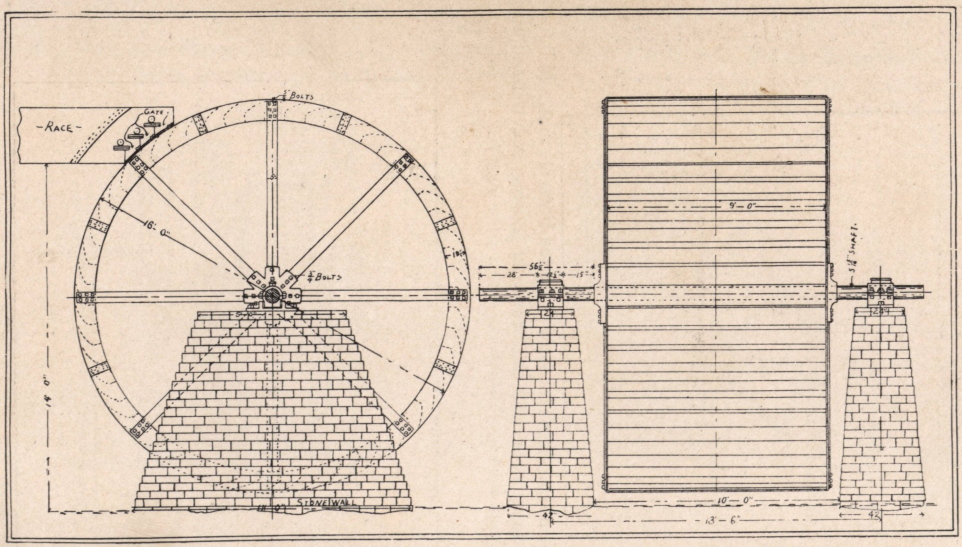
A direct drive, doing away with the heavy old gearing and transmitting the power with the least loss by friction.

D



I-X-L with Segment Gear to drive Roller Mill, Cotton Gin, Buhrs, Etc.

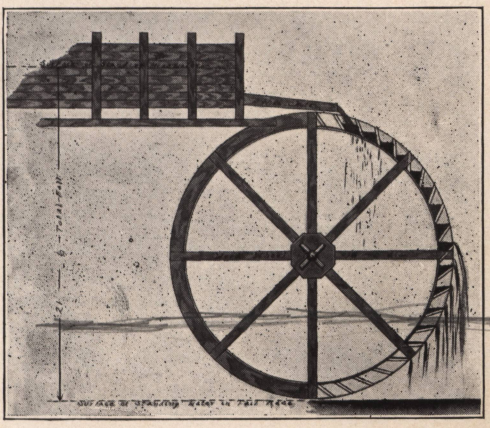
This is our most popular plan and the one which will give the most power with the least water. Especially adapted to places where turbines have been used.



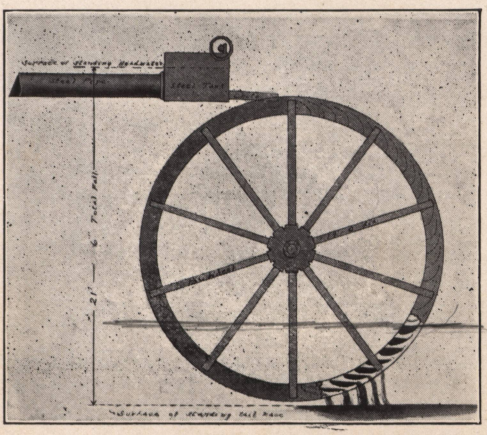
I-X-L STEEL PITCH BACK WATER WHEEL

This type of wheel resembles the overshot wheel at many points, but the water is applied at some point below the top and above the centre of the wheel. There is very little difference in efficiency between the overshot and the pitchback, on falls of ten feet or more, but owing to its larger diameter the pitchback costs more money, therefore we generally recommend the overshot for ordinary locations. For those who prefer the pitchback, we build it as it should be built. It is just the thing where two streams of different heads are to be used.

SOME DIFFERENCES BETWEEN WOOD AND STEEL WHEELS.



It is generally possible to install a steel wheel of larger diameter than the wood wheel which it displaces. The illustrations on this page show a 19 ft. dia. steel wheel working under the same head required to operate an 18 ft. wood wheel. (In measuring for the head or fall, always measure the vertical distance from surface of standing water in head race or forebay to surface of standing water in tail race.) To get the water into the thick clumsy buckets of the wood wheel it is necessary to give the chute about 6 inches fall and to run it past the vertical center line of the wheel. Several inches fall must also be wasted between the wood chute and the wood buckets, and several inches more between the tail race and the bottom of the wood wheel, for backwater is fatal to its efficiency. This waste of head causes considerable waste of power. The wood wheel utilizes none of the percussive force of the head of water in the forebay, while the I-X-L gets nearly all of it, owing to the shape of our buckets and the method of applying the water.



A water-soaked wood wheel weighs three times as much as a steel wheel and the friction of the bearings is very many times greater. No wood wheel can be kept in balance and it is evident that much power is wasted by leaking, splashing and discharging the water too soon. These are losses that can not be overcome, no matter how well the wood wheel is built. None of them affect the I-X-L.

MEASUREMENT OF WATER

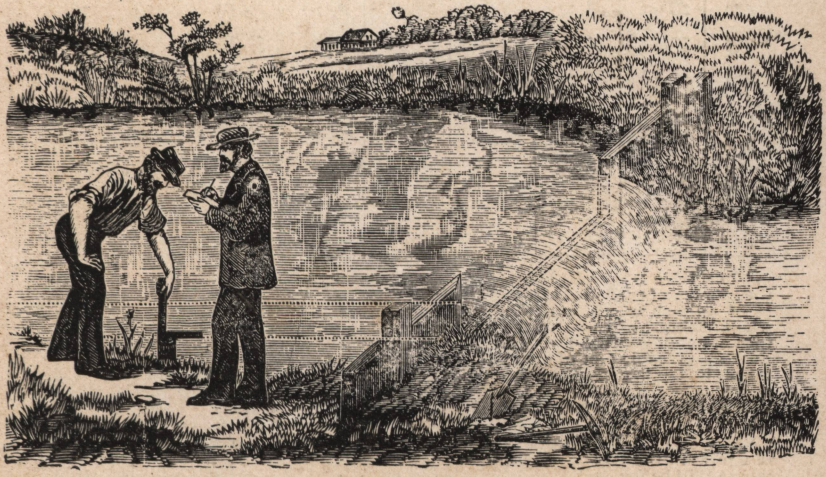
IT IS highly important to those who contemplate improving or utilizing their water power to determine the head that can be secured—that is, the vertical distance from the surface of tailwater to the surface of head water. Then ascertain the amount of water that can be relied upon. It would not be prudent for parties to subject themselves to an expense without having the assurance of having power sufficient to propel their proposed machinery. It has frequently occurred that mills and factories have been completed, and not until then the mistake discovered.

By knowing the head and the number of cubic feet of water that flows per minute, the size of wheel that is best adapted can be selected and the horse-power determined. We would, therefore, recommend, when convenient, to get some one who is skilled in hydraulics to make the calculations; however if this cannot be conveniently done, parties can measure their streams themselves by methods which we propose. There are many ways by which streams of water can be measured approximately, but, undoubtedly, the most correct way in which it practically can be done, is by means of a "Weir Dam," as shown on page 31. If the stream is not too large, take a board, or, if required, joint and nail together with cleats more than one, wide and long enough to form a dam across the stream; cut a notch in the top of the board of sufficient depth to allow all the water to pass through. The length of said notch should not be more than half or two-thirds the width of dam, and should be beveled on the down side of the stream nearly to a feathered edge; be particular to have the notch level across the stream so the water will be of the same depth at both ends. Drive a stake in the ground about four feet up the stream from the board, so that the top of the stake will be on a level with the bottom of said notch, which can readily be seen when the water begins to flow over it. When the dam is made perfectly tight, so that all the water passes through the notch or Weir, and the water raised to its maximum height, measure carefully how much the water raises above the top of the stake, which measurement is the basis from which the calculations are made to find the amount of water that flows per minute, as shown in the Weir Table on page 32. Care must be taken to get a board wide enough to dam the water to a dead level before it begins to flow over the notch, and that the water has a fall, enough to clear itself below—say a depth of six or seven inches, or more in a large stream.

Another matter of importance is the possibility of storing the water by means of a dam or pond, by which machinery can be run a portion of the time when the regular flow of the stream is sufficient—say, if the location admits, a dam or pond can be constructed so as to store the water through the night to be used through the day, or store and use as the case may suit; thus, if the water can be stored for twelve hours, the next twelve the power will be double that of the regular stream.

If the stream is too large to measure by means of a Weir as described, select a place in the stream that is smooth, and an even flow, throw in a float of sufficient weight to sink well into the water, and time its passage from one fixed point to another. It should be repeated several times and at different places across the stream, so as to be enabled to get the average velocity of water in the stream. Measure its width and average depth, by measuring at several places across. If the float is large and heavy enough to sink nearly to the bottom, the result will be more correct, because water flows faster at the top than at the bottom of a stream. If parties measure their streams in the above way, and send us the facts, including the head that can be procured, estimates will be made and returned to them by mail.

We emphatically state that there is no water power in existence unless under very low heads, which cannot be very much improved by the use of our I-X-L Steel Overshoot Water Wheel. No difference whose make or what kind of a wheel is used, we can increase your power 25 to 50 per cent. This is especially true of light streams, where the economical use of water is an object.



SHOWING WEIR DAM AND MEASUREMENT OF WATER.

THE WEIR TABLE

	0	⅛	¼	⅜	½	⅝	¾	⅞
0	.00	.01	.05	.09	.14	.19	.26	.32
1	.40	.47	.55	.64	.73	.82	.92	1.02
2	1.13	1.23	1.35	1.46	1.58	1.70	1.82	1.95
3	2.07	2.21	2.34	2.48	2.61	2.76	2.90	3.05
4	3.20	3.35	3.50	3.66	3.81	3.97	4.14	4.30
5	4.47	4.64	4.81	4.98	5.15	5.33	5.51	5.69
6	5.87	6.06	6.25	6.44	6.62	6.82	7.01	7.21
7	7 40	7.60	7.80	8.01	8.21	8.42	8.63	8.83
8	9.05	9.26	9.47	9 69	9.91	10.13	10.35	10.57
9	10.80	11.03	11.25	11.48	11.71	11.94	12.17	12.41
10	12.64	12.88	13.12	13.36	13.60	13.85	14.09	14.34
11	14.59	14.84	15.09	15.34	15.59	15.85	16.11	16.36
12	16.62	16.88	17.15	17.41	17.67	17.94	8.21	18.47
13	18.74	19.01	19.29	19.56	19.84	20.11	20 39	20.67
14	20.95	21.23	21.51	21.80	22.08	22.37	22.65	22.94
15	23.23	23.52	23.82	24.11	24.40	24.70	25.00	25 30
16	25.60	25 90	26.20	26.50	26 80	27.11	27.42	27.72
17	28 03	28.34	28.65	28.97	29.28	29.59	29.91	30.22
18	30.54	30.86	31.18	31.50	31.82	32.15	32.47	32.80
19	33.12	33.45	33.78	34.11	34.44	34.77	35.10	35.44
20	35.77	36.11	36.45	36.78	37.12	37.46	37.80	38.15
21	38.49	38.83	39.18	39.53	39.87	40.22	40.57	40.92
22	41.27	41.62	41.98	42.33	42.69	43.04	43.40	43 76
23	44 12	44.48	44.84	45.20	45.56	45.93	46.29	46.66
24	47.03	47.39	47.76	48.13	48 50	48.87	49 24	49.62

This table is to assist in ascertaining the capacity of a stream of water. It gives the number of cubic feet of water that will pass over a Weir one inch wide, and from ⅛ of an inch to 24⅞ in depth. The figures on the first upright column represent whole inches, and those on the top horizontal line represent fractional parts of an inch of depth over the Weir. The figures on the second upright column indicate the number of cubic feet of water that will flow per minute over the Weir, for whole inches in depth, and on the succeeding column whole inches and the fractions under which they occur. Then the number of cubic feet thus found, multiplied by the width of the Weir in inches, will give the capacity of a stream.

EXAMPLE.—To find the required number of cubic feet of water that will flow over a Weir, 6½ inches in depth and 50 iuches in width, follw down the left hand column of figures in the table to 6, then across, until directly under the ½ in the top line, where Will be fouud 6.62; this, multiplied by 50, will give 331, the number of cubic feet of water that passes over the whole Weir.

MEASUREMENT OF LARGE STREAMS.

In streams too large to measure by Wier, the quantity of water is usually determined by "float measurement." In the use of this method it is important that the float be so made that it sinks well into the water. The measurements should be taken at a point where the velocity is not too great, and where the bed of stream is uniform. If the stream be wide, the velocity in feet per minute should be taken near the shore and in the centre; the average then is the velocity of the stream.

To ascertain the cubic feet of water, multiply the depth by the width; multiply this product by the velocity in feet per minute, and the result will be the number of cubic feet flowing per minute.

MEASUREMENT OF WATER THROUGH OPENINGS UNDER PRESSURE.

Table Giving the Number of Cubic Feet of Water Discharged per Minute, by an Orifice 1 Inch Square, under any Head from 3 to 62 Inches.

HEAD	CUBIC FEET	HEAD	CUBIC FEET	HEAD	CUBIC FEET	HEAD	CUBIC FEET	HEAD	CUBIC FEET	HEAD	CUBIC FEET
3	1.12	13	2.20	23	2.91	33	3.47	43	3.95	53	4.39
4	1.27	14	2.27	24	2.97	34	3.52	44	4.00	54	4.42
5	1.41	15	2.36	25	3.03	35	3.57	45	4.05	55	4.46
6	1.53	16	2.44	26	3.09	36	3.63	46	4.10	56	4.52
7	1.64	17	2.51	27	3.15	37	3.67	47	4.13	57	4.55
8	1.75	18	2.58	28	3 20	38	3.72	48	4.18	58	4.58
9	1.85	19	2.65	29	3.26	39	3.77	49	4.22	59	4.63
10	1.94	20	2.72	30	3.32	40	3.82	50	4.27	60	4.66
11	2.03	21	2.78	31	3.37	41	3.86	51	4.30	61	4.72
12	2.12	22	2.85	32	3.42	42	3.92	52	4.34	62	4 74

Suppose the opening to let the water on an overshoot wheel be 36 inches long and the gate hoisted 2 inches; the head of wheel above the centre of opening, 26 inches. Multiply the length, 36, by 2, (the height the gate is hoisted,) and the result will be 72, the number of square inches in opening.

By referring to the foregoing table, opposite 25 inch head will be found 3.03; this multiplied by 72 gives 218.16, the number of cubic feet of water.

MEASUREMENTS IN MINER'S INCHES.

A miner's inch is the quantity of water that will flow through an orifice one inch square when the head above the centre of the orifice is six inches. This is but an approximate definition, as the "miner's inch" seems to be differently understood in different sections. It ranges in value from 1.20 to 1.76 cubic feet per minute, but with a head of six inches is about 1.60 cubic feet per minute.

When correspondents speak of miner's inches they should accompany their statement by a description of the kind of miner's inch they have in view, when writing. As we have before intimated, the amount of pressure over the opening differs in different parts of the country, or in different mining districts, and each depth, or miner's inch, will discharge differently. The kind of miner's inch we have described above, is one that is generally used.

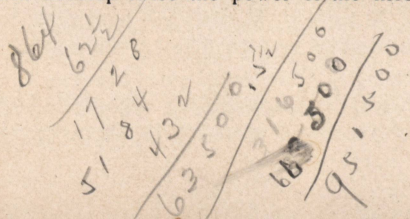
A miner's inch is a measure for flow of water, and is an opening one inch square in plank, 2 inches thick, under a head of 6 inches of water to upper edge of opening.

TO COMPUTE HORSE POWER.

A horse power is the amount of power required to raise 33,000 pounds one foot per minute. To compute the horse power of any stream, multiply the number of cubic feet of water it flows per minute by 62½ (which is the weight in lbs. of one cu. ft.) Multiply that product by the head (in feet) and divide the product by 33,000. The quotient will be the full horse power of the stream.

Most turbine manufacturers claim that their wheels will develop 80 per cent efficiency, but it is well known that very few of them in actual use will ever reach 70 per cent efficiency and then only under the most favorable conditions.

The I-X-L will develop 95 per cent efficiency, or at least a third more than other wheels using the same amount of water. It will develop just as high efficiency at one-third or one-fourth capacity as it will when run at normal capacity. A turbine will do practically no work at all when run much below full gate, so that in the course of a year's run on a variable stream, the I-X-L will develop twice the power of the most economical turbine.



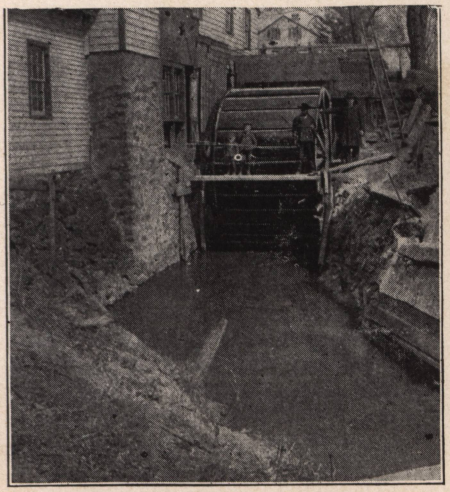
WATER WHEEL TERMS.

The efficiency of a water wheel is the actual horse power which it develops with a certain amount of water as compared with the power which it is theoretrically possible to develop with that amount of water. It is impossible to develop the full theoretical power for there must always be some loss but the nearer a wheel approaches this performance, the higher its efficiency. Thus when you have calculated the horse power a stream affords by one of the methods we have described, you can depend on nearly 95 per cent. of this power if an I-X-L is used, but only on 60 to 70 per cent. if a turbine or wood wheel is used. This difference in efficiency becomes much greater when it is necessary to run at part gate or after the wheel has been used a few years.

Back-water occurs when the tail race from the wheel becomes clogged or choked so that the wheel has to wade in the water it discharges.

The Jack Shaft is the shaft which carries the pinion wheel which gears into the segment gear.

The Segment, or Segment Gear, as the name indicates, is a gear wheel composed of a number of pieces which are segments of a circle. It is bolted to the arms or housings of the water wheel. The segment gear as we make it, is quite a different thing from the rude and troublesome device employed on the old wood wheels. (See page 24 for illustration.)



13 FT. BY 8 FT. I-X-L WHEEL

At mill of C. P. Fox, DARETOWN, N. J., taking the place of two of the best turbines on the market. Previous to installing the I-X-L, Mr. Fox never run his roller mill without steam. Now he runs both mills by water power entirely.

A Pinion is a small gear wheel which gears into a larger one.

A Master Wheel is the large gear wheel which is keyed to the water wheel shaft instead of being bolted to the wheel itself like the segment gear. (See page 25 for illustration.)

The Chute is the short trough of wood or iron which conveys the water from the gate to the buckets of the water wheel. It is generally about 3 ft. long.

HYDRAULIC INFORMATION

ONE cubic foot of water	62.378 lbs.
One cubic inch of water	0.36 lbs.
One gallon of water	8.338 lbs.
One gallon of water	231 cu. in.
One cubic foot of water	7.476 gal.
One pound of water	27.7 cu. in.

Water falling is actuated by the same laws as falling bodies; passing through 1 foot in ¼ of a second, 4 feet in ½ a second, 9 feet in ¾ of a second, and so on. Hence its velocity in flowing through an aperture in the side of a reservoir, bulkhead, or any vessel, is the same as a heavy body falling freely from a height equal to the distance from the middle of the aperture to the surface of the water.

To find the loss of head by water entering a pipe in which the mouthpiece is straight, multiply the square of the velocity by .0076 and the product will be the approximate loss in feet.

The loss of head by friction in a pipe increases directly with the length, with the square of the velocity, and with the roughness of the pipe. It decreases as the diameter of the pipe increases and is independent of the pressure or head of water.

To find the loss in feet: – Divide the product of the length and the square of the velocity in feet per second by the diameter in inches and then multiply this quotient by 0.0056 for pipes up 6 inches diam.; by 0.0047 for pipes between 6 inches and 21 inches diameter; by 0.0037 for pipes between 21 inches and 48 inches diameter; by 0.0028 for pipes between 48 inches and 72 inches diameter, and by 0.0019 for pipes larger than 72 inches diameter. This formula will give approximate results within at least 10 per cent. of correctness for smooth straight pipe.

Roughly speaking, the loss of head in 100 feet of pipe is equivalent to one-half the velocity squared, divided by the diameter of the pipe in inches.

To find the friction head necessary to give a required velocity in an open flume or canal: Multiply 0.001 the length in feet by the square of the velocity in feet per second, and by the sum of the two side measurements, the bottom width and one-tenth the top width; and finally divide the product thus obtained by the number of square feet in the section of the stream, and this quotient will be the loss of head in the stream in question.

To compute the mean depth of flowing water:—Rule—Set off the breadth of the stream, etc., into any convenient number of divisions; ascertain the depths of these divisions; then divide their sum by the number of divisions, and the quotient is the mean depth.

To compute the mean area of flowing water:—Rule—Multiply the breadth or breadths of the stream, etc., by the mean depth or depths, and the product is the area.

To compute the volume of flowing water:—Rule—Multiply the area of the stream, etc., by the mean velocity of its flow in feet, and the product is the volume in cubic feet.

The weight of water varies with the temperature somewhat, but in ordinary calculations we estimate it at 62⅓ pounds per cubic foot.

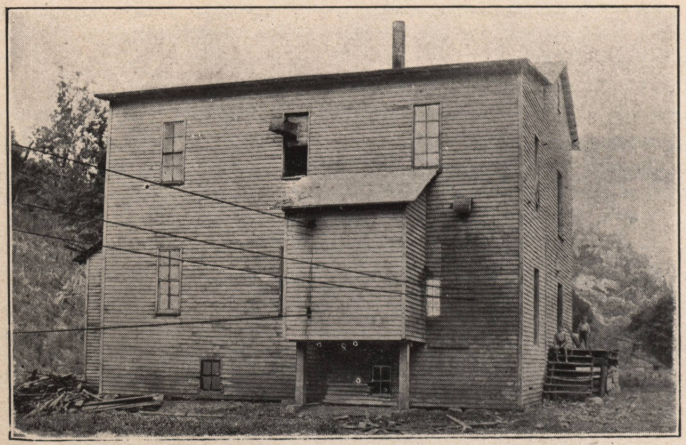
A cubic foot is equal to 1728 cubic inches or 7½ gallons.

To find the pressure in pounds on each square inch, multiply the head by 0.434, or divide by 2.30. Each 2.30 feet in height increases the pressure one pound.

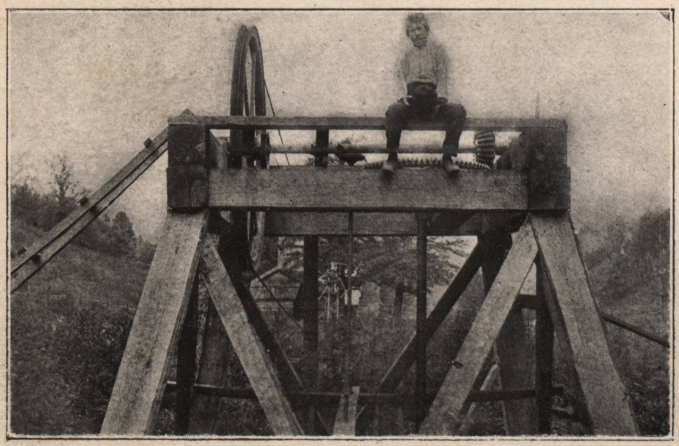
13 FT. BY 8 FT FACE, I-X-L STEEL OVERSHOOT AT MILL OF DR. J. H. TRIPLETT, MT. JACKSON, VA., WHICH DISPLACED A WOOD WHEEL AND INCREASED THE POWER 100 PER CENT.

AN INTERESTING INSTALLATION.

The accompanying cuts show how power is transmitted from a 28 ft. diameter I-X-L Steel Overshoot to the mill of N. B. Kittrell at Masada, Tenn.



The water wheel is located in a cave in the solid rock and discharges its water into an underground river. The top of the wheel is 20 ft. below the surface of the ground, and the power is transmitted to the surface by bevel gearing and upright shaft and thence to the mill, a distance of over 375 ft., by a single span wire rope. The small rope drive shown in cut is used to start and stop the wheel from the mill.



WHAT AUTHORITIES SAY ABOUT OUR WHEELS.

It has so long been the custom among all writers on Hydraulics to treat the overshot as an out-of-date wheel, that it is very hard for them to acknowledge that they were mistaken and that the I-X-L Steel Overshoot as we build it to-day is the very highest type of water wheel in existence. But, however unwillingly, they are gradually coming to admit this fact, as can be seen from the following quotations from the latest books, technical papers, etc. Although they still balk at admitting that we can develop 95 per cent. efficiency, the remarks here quoted should be considered a very great concession in the light of their former writings:

"The efficiency of the overshoot is very high, ranging to 90 per cent. In times of drought and shortage of supply the efficiency is highest. Herein lies its great advantage.—Merriman's 'Treastise on Hydraulics.'"

"Many small powers now going to waste, can at small expense, be made to yield big returns in grinding, sawing and electric lighting. A water power where an expensive dam is not needed—and there are thousands of this kind—is a very valuable possession. Overshot water wheels are now made of steel which has many advantages over the old wood wheels. The steel wheels do not swell or warp, they carry more water and give more power, and are made in all sizes from a few feet in diameter up.—From 'Popular Mechanics.'"

"The I-X-L Steel Overshoot Water Wheel will develop at least one-third more power than a turbine, using the same amount of water, or 25 per cent. more power than any wood wheel. This has been tested and proved so often that it scarcely needs any further demonstration. In many cases the power over standard makes of turbines has been doubled.—A. B. Hamaker, writing on 'Water Power Economy' in Operative Miller."

"It is undoubtedly possible to make available for the actual work to be done, 90 per cent. of the energy of the water with all wheels 18 ft. diameter and upwards. As they are enlarged in diameter above that figure, the efficiency becomes more and more assured. * * * * It is true that those in possession of ancient text books will find in them a credit of 66 per cent. to overshot wheels, which was probably a fair lifetime average for such wheels as were built by the ancient millwrights; and probably a good average yield for the wheels built by the backwoods millwrights of to-day. * * * * It might as well be understood, however, that when it is said that 90 per cent. of power is possible with the best constructed overshot wheels, wooden wheels are not meant. The high per cent wheels must be made of metal.—From the 'Miller and Millwright' by Abernathy."

"The receipt of your booklet on steel overshoot water wheels will be appreciated. The high efficiency of this class of wheels is recognized, and if the Reclamation Service has occasion to use wheels of this character, it will be pleased to investigate your make.—U. S. Geological Survey."

"The efficiency of the overshot water wheel is high * * * ranging to 90 per cent. in the best constructed wheels.—From 'The Elements of Hydraulic Engineering,' International Correspondence Schools."

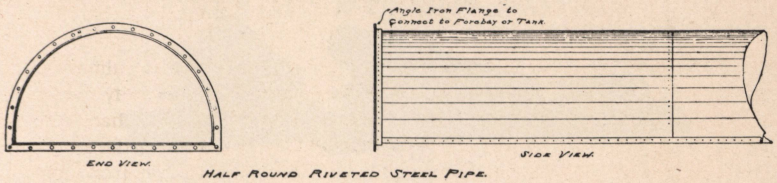
RIVETED STEEL WATER PIPE.

The use of steel pipe in place of wood forebays originated in California, where it is extremely popular. The rest of the country is now rapidly recognizing its value. The first cost of steel pipe is considerably more than terra cotta, but it is so much cheaper to instal that the final cost is almost the same. Unlike terra cotta, it will stand almost any amount of pressure and can follow the lay of the ground instead of having to have a straight ditch dug for it. It is more durable, will not leak, and is not liable to breakage.

Our pipe is well riveted with Norway rivets, close together. After riveting it is well caulked, to prevent leakage, and covered with asphaltum varnish inside and outside, to prevent rusting. It is perfectly round and true to size.

PRICE LIST OF RIVETED PIPE.

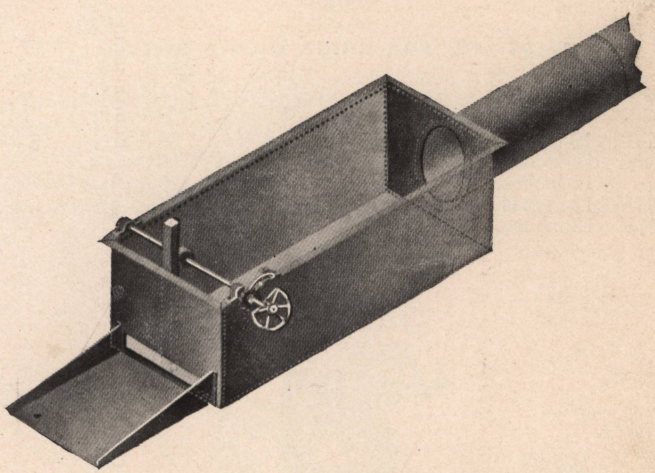
Diameter of pipe in inches.	Thickness by Stubbs gauge.	Equivalent in inches.	Price per lineal foot.	Diameter of pipe in inches.	Thicknessby Stubbs gauge.	Equivalent in inches.	Price per lineal foot.
12	No. 14	5/64	$1.40	22	No. 7	3/16	$3 70
14	14	5/64	1.50	24	14	5/64	2.40
14	12	7/64	1.75	24	12	7/64	2.70
14	10	9/64	1.95	24	10	9/64	3.10
16	14	5/64	1.75	21	8	11/64	3 50
16	12	7/64	2 00	24	7	3/16	4.00
16	10	9/64	2.25	30	14	5/64	2.90
16	8	11/64	2.50	30	12	7/64	3.30
18	14	5/64	1.90	30	10	9/64	3.70
18	12	7/64	2.20	30	8	11/64	4.10
18	10	9/64	2.45	30	7	3/16	4.45
18	8	11/64	2.77	36	12	7/64	3.85
20	14	5/64	2 03	36	10	9/64	4.40
20	12	7/64	2 40	36	8	11/64	5.00
20	10	9/64	2 70	36	7	3/16	5.50
20	8	11/64	3.00	42	8	11/64	6.10
20	7	3/16	3 35	42	7	3/16	6.50
22	14	5/64	2.20	48	7	3/16	7 50
22	12	7/64	2.50				
22	10	9/64	2.90				
22	8	11/64	3.37				



HALF ROUND RIVETED STEEL PIPE.

OUR HALF-ROUND OR D-SHAPED PIPE.

The advantages of this style of pipe are apparent at the first glance. There is no loss of head in the half-round pipe, for flow of water can always be maintained the full width of the pipe. A round pipe must be at least half full to get much water through it, while the half-round or "D" pipe can carry just the natural flow of the stream. Prices upon application.



STEEL TANKS AND PIPE.

Our steel tanks are almost as far ahead of the old-style wood forebay as the I-X-L is ahead of the wood wheel. Iron pipe is used to convey the water from the dam or race way to the tank, from which it is discharged to the wheel through our water-tight iron gate, thus making a complete and permanent water-tight job. This method of conveying the water is immensely more satisfactory than the use of dirt raceways, which are always breaking out, and wood flumes which are always rotting. In many cases too, even the first cost is less than that of the leaky wood flumes.

CHAIN OILING BOXES.

This cut shows our improved babbitted journal boxes. The base of the box is cored to form an oil reservoir. The chains are made loose enough to allow them to dip into the oil constantly, thus carrying the oil over the shaft at each revolution. If sufficient oil is placed in the box before starting the machinery the shaft will run from six to eight months without refilling. The boxes are so constructed that they may be easily cleaned by filling with kerosene.

PRICE LIST FOR CHAIN OILING BOXES.

Diameter of Shaft.	Length of Bearing.	Price.	Diameter of Shaft.	Length of Bearing.	Price.
2 7/16	10 inches.	$ 7.50	4 7/16	15 inches.	$18.00
2 15/16	12 inches.	8.75	4 15/16	15 inches.	22.00
3 3/16	12 inches.	10.00	5 7/16	16 inches.	25.00
3 7/16	12 inches.	12.00	5 15/16	17 inches.	30.00
3 15/16	15 inches.	15.00			

Discount..... .....

SET COLLARS.

PRICE LIST.

Size.	Price	Size.	Price.	Size.	Price.	Size.	Price.
1 3/16....	$ .65	2 3/16 ...	$1.70	3 3/16...	$2.40	4 7/16	$3.45
1 7/16....	1.05	2 7/16....	1.80	3 7/16....	2.75	4 15/16	3.75
1 11/16...	1.26	2 11/16...	2.05	2 11/16...	2.95	5 7/16	4.25
1 15/16...	1.45	1 15/16...	2.20	3 15/16...	3.20	5 15/16	4.50

PRICE LIST OF FINISHED SHAFTING.

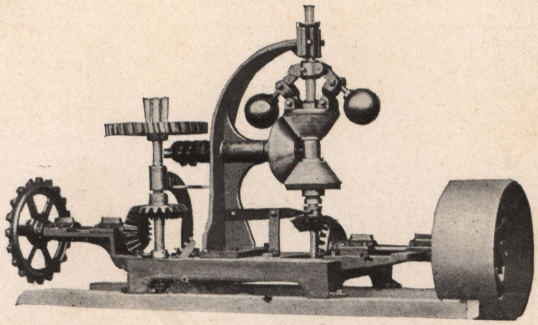
Diameter.	Weight per Foot.	Price.
1 7/16	5.47	$ .38
1 11/16	7.58	.48
1 15/16	10.00	.62
2 3/16	12.75	.80
2 7/16	16.00	1.00
2 11/16	18.98	1.25
2 15/16	23.00	1.42
3 3/16	26.95	1.77
3 7/16	31.56	2.17
3 15/16	35.60	2.45
3 11/16	40.59	2.80
4 3/16	45.00	3.50
4 7/16	51.55	3.95
4 15/16	63.82	4.80
5 7/16	77.40	7.00
5 15/16	91.29	8.90
6 7/16	108.05	11.25
6 15/16	126.00	14.00
		Discount.....

Larger sizes at Special Rates.

The diameter of Shafting conforms to Standard guage and any deviation therefrom will be charged extra.

Boxing extra, at cost. Not responsible for safe and prompt delivery after shipment.

In ordering shafting give size, length and place of journals and key ways.

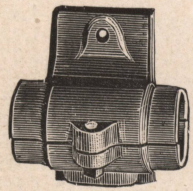


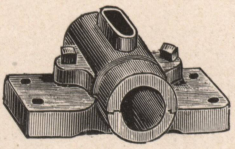
THE I-X-L WATER WHEEL GOVERNOR.

This is a governor for controlling overshoot water wheels for planing mills, electric light plants, and all factories where the power used varies considerably. It is simple in construction but very sensitive and reliable.

The governor is set inside the mill or at any convenient point near the water wheel and is driven by it from the jack shaft or line shaft to 100 revolutions per minute. It is connected to the gate shaft by link-belt or sprocket chain, and can be instantly thrown in or out of gear when desired.

RIGID FLAT BASE CLAMP AND POST BOXES.





PRICE LIST.

Diameter of Box.	Length of Bearing.	Price.
1 3/16	4½	$ .80
1 5/16	4½	1.00
1 7/16	4½	1.15
1 11/16	5	1.50
1 15/16	6	2.00
2 3/16	7	2.65
2 7/16	7½	2.90
2 11/16	8	4.00
2 15/16	9	5.00
3 3/16	10	5.50
3 7/16	11	6.25
3 11/16	12	7.35
3 15/16	13	8.00
4 7/16	14	11.50
4 15/16	15	15.75

Discount.....

The bearings of these Hangers and Boxes have been used for months without requiring any attention or replenishing with oil. The cheapest kind of oil can be used and will answer as well as the most expensive, so long as it remains fluid.

The prices above are for plain bored. If babbitted boxes are required, 20 per cent. addition will be added.

ROLLER BEARING BOXES.

Our improved Roller Bearings are furnished with all our wheels if desired. The rollers are made of the best high-carbon steel and are guided by brass cages at each end, which are turned perfectly true on all sides. The lower halves of the boxes contain oil reservoirs which feed the oil to the rollers by capillary attraction. By a simple device the bearings may be quickly cleaned when desired. These bearings run with an astonishingly small amount of friction. Our largest wheels, when equipped with our roller bearings, can be turned by a few pounds weight.

GEARING

WE are well equipped with a full line of Gear patterns, and can furnish anything in this line at a very moderate price at short notice. Our gears are made of first class material by expert mechanics. The use of Gearing, so popular years ago, is still continued where a positive motion is desired. The objections to its use are the consequent noise (unless mortised cogs are used,) its inadaptability to high speeds, and the necessary delays for repairs in case of wearing out or breaking of teeth.

Gears with correctly proportioned teeth, if true and correctly meshed, have been run with good results as high as twenty-two hundred (2,200 ft.) feet per minute, at the pitch line for gearing, and three thousand (3,000 ft.) feet for wood and iron gearing, but such speeds are excessive, and should be avoided where possible.

Gears should be mounted on heavier shafts than are necessary merely to transmit the power, as they exert considerable deflective stress upon the shafts.

Bearings supporting gears or jack shafts, should be placed as near as possible to the gears, and be securely bolted to heavy iron yokes or wood bridge-trees.

Various rules have been advanced as to the power transmitted by Gearing. It is hardly advisable to allow the placing of all the stress on a tooth it will safely carry while new, as it has been found that under such conditions the abrasion between the two gear wheels is so considerable that the wearing away of teeth will proceed and rapidly diminish the proportions of the tooth below what it should be for the load thereon, and as a result we have breakage or renewal of teeth to contend with. Neither is it good practice to so proportion the wheels that they will be so bulky and cumbersome as some of the old formulae demand.

The following table shows the greatest horse-power which different kinds of gears of 1 inch pitch and 1 inch face will safely transmit at various pitch line velocities. To find the greatest horse-power which any other pitch and face will safely transmit, the following rule can be used:

Rule 5.—Given —— the pitch (in inches,) face (in inches,) velocity of pitch circle (in feet per second, and kind of gear; to find — the greatest horse-power that can be safely transmitted.

First.—Find the horse-power in the table which the given kind of wheel with 1 inch pitch and 1 inch face will transmit at the given velocity.

Second.—Multiply the pitch by the face.

Third. - Multiply the horse-power found, by the product of pitch by face. The final product is the horse power required.

Example.—What is the greatest horse-power that a bevel wheel, 43 in. pitch diameter, 2 in. pitch, 6 in. face, and 125 revolutions per minute, will safely transmit?

From previous example we have found the pitch line velocity to be 23.4 feet per second, which is nearest to a velocity of 24 feet per second in the table.

First—The horse-power which a bevel wheel of 1 in. pitch and 1 in. face will transmit is (from table,) at this velocity, 4.931.

Second.—The product of pitch by face is $2 \times 6 = 12$.

Third.—$12 \times 4.931 = 59.17$, horse power.=Answer.

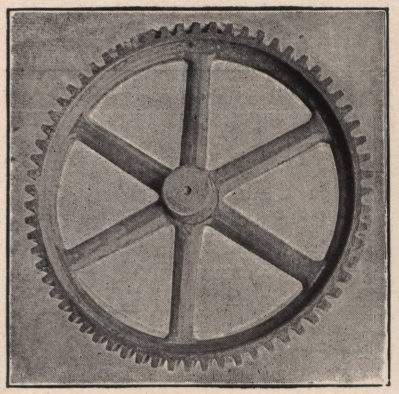
Whenever it is desirable to know about the average horse-power that any wheel will transmit, ⅔ or ½ of the results obtained by the rule above should be taken.

A horse-power in machinery is estimated at 33,000 pounds raised one foot high in a minute.

Table Showing the Horse-Power which Different Kinds of Gear Wheels of One Inch Pitch and One Inch Face Will Transmit at Various Velocities of Pitch Circle.

1	2	3	4	5
Velocity of Pitch Circle in Feet per Second.	Spur Wheels.	Spur Mortise Wheels.	Bevel Wheels.	Bevel Mortise Wheels.
2	1.338	.647	.938	.647
3	1.756	.971	1.227	.856
6	2.782	1.76	1.76	1.363
12	4.43	3.1	3.1	2.16
18	5.793	4.058	4.058	2.847
24	7.025	4.931	4.931	3.447
30	8.182	5.727	5.727	4.036
36	9.163	6.414	6.414	4.516
42	10.156	7.102	7.102	4.963
48	11.083	7.680	7.680	5.411

GEAR WHEEL TERMS.



SPUR GEAR.

The Pitch Line of a wheel is the circle upon which the pitch is measured, and it is the circle which determines the diameter and circumference of the wheel, and upon which the velocity is measured.

The Pitch is the arc of the circle of the pitch line, between the centers of two adjacent teeth.

The true, or "Chordial Pitch," or that by which the teeth are spaced, is a straight line drawn from centre to centre of two contiguous teeth upon the pitch line.

The "Line of Centres" is the line between the centres of two wheels.

The "Pitch Radius" is the semi-diameter running from the centre to the pitch line.

The "Length of a Tooth" is the distance from its base to its extremity.

The "Breadth of a Tooth" is the distance across the face of the wheel.

The "Thickness of a Tooth" is measured on the pitch line, and is little less than half the pitch.

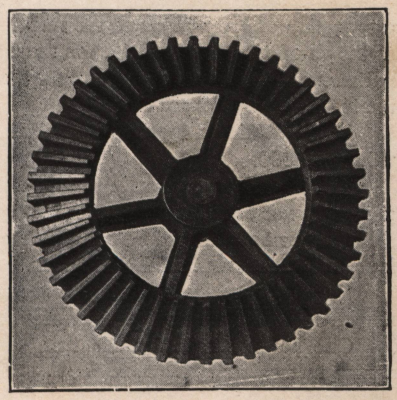
A "Mortise Wheel" is a wheel the rim of which is constructed with mortises, for the reception of wooden cogs, which are fitted into the mortises and keyed tight on the inside of the rim.

A "Spur Wheel" is a wheel having its teeth parallel to its axis.

A "Bevel Wheel" is a wheel having its teeth at an angle with its axis.

A "Miter Wheel" is a wheel having its teeth at an angle of 45 degrees with its axis.

When two wheels act upon one another, the greater is termed the wheel and the lesser the pinion.



BEVEL GEAR.

BELTING

THE transmission of power by Belting, whether leather, rubber, cotton, or any of the combinations or forms of these materials lately placed on the market, is general: We are aware of no simple rule that is applicable to every situation and circumstance, for the determination of the size of belts necessary to transmit a required power.

The highest speed at which belts should or can very well be run on iron pulleys is eight thousand (8,000 ft.) feet per minute. Such speed, however, is excessive, and where possible should be avoided. Centrifugal force very much modifies the carrying capacity of belts in motion; the tendency being to lift the belt from the surface of the pulley. This tendency must be met by a greater stress in stretching the belt, which is apt to injure the bearings while at rest.

We place below two formulae which we have found of assistance in roughly determining the power of leather belting. The first represents the transmitting capacity of the belt itself, independent of contact or centrifugal force, and is based on an assumption of 330 pounds per square inch as a safe working strain, or 55 pounds per inch width of face for single leather belt, one-sixth of an inch thick.

H. P.—=Velocity in ft. per Min. $\times$ width of belt in in. divided by 600.

The second formula, the more reliable of the two, is based upon the assumption of 330 pounds as the safe strain for leather belt, or 50 per cent. as the co-efficient friction between the belt and the pulley and upon experiments that seem to prove that the power transmitted is proportional to the length of contact arc on pulley.

H. P.=Width in inches $\times$ velocity in feet per Min. $\times$ contact in ft. divided by 5500.

These formulae are for single belts, one-sixth inch thickness. The transmitting power of thicker belts increases proportionately with thickness.

Leather belts should be run with the grain or hair side next to the pulley; they wear longer and hold better.

Long belts as nearly horizontal as possible give best results, as the corresponding heavier weight gives tension to the belt and pressure on the pulley.

One pound single leather belt, one-sixth inch thick, will cover 1.2 square feet.

Single leather, four-ply rubber, and four-ply cotton belting will transmit equal power.

HORSE POWER SAFELY TRANSMITTED BY SINGLE LEATHER BELTING AT A SPEED OF 100 FEET PER MINUTE.

Width of Belt in Inches.	Horse Power
2 inch Belt	.18
4 " "	.36
6 " "	.55
8 " "	.74
10 " "	1.00
11 " "	1.10
12 " "	1.20
14 " "	1.37
16 " "	1.55
18 " "	1.75

If the belt is to travel 200 feet per minute it can be depended upon to transmit twice the power of above table, or six times as much for 600 feet per minute travel, or twelve times as much for 1200 feet travel, etc.

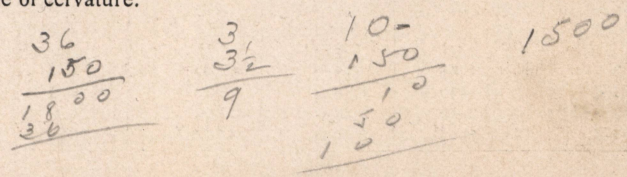
Single leather belting and good quality 4-ply rubber or stitched canvas belting will transmit an equal amount of power.

TO CALCULATE LENGTH OF BELTING.

To find the length of belt wanted:—Add the diameters of the two pulleys together, divide the result by two, and multiply this quotient by 3⅛. Add this last product to twice the distance between the centers of the two shafts, and you have the length of the belt required.

To find the change required in the length of belt when one of the pulleys on which it runs is changed for a different size:—Take three times half the difference between the diameters of the two pulleys and the result will be the length of belt to be cut out or put in.

Tighteners:—The tightening pulley is applied to the belt to increase its adhesion to the pulley, and as this is to fall first on the smaller pulley, it is usual to place it on the slack side of of the belt near this pulley in order to increase the area of contact as well as adhesion. It also increases the friction of driving in proportion to the thrusting of the belt from the line of its natural line of ccrvature.



MANILA ROPE TRANSMISSION.

MANILA ROPE TRANSMISSION, as a method of utilizing power, has been used successfully in England for some time. The efficiency of manila rope at high speed, its positive transmission, its compactness, its noiselessness, the ease with which its slack can be taken up, and the readiness with which it may be carried around corners and to almost any position, whether near or at a distance, all recommend its use to engineers and power users generally.

In making a splice, great care should be taken to have it long and tight.

Pulleys should be made as large in diameter as convenient and at least 40 times the diameter of the rope.

If obliged to use small diameter pulleys, use smaller ropes and more of them, as the resistence to bending decreases with the size.

Small wheels bend the rope quickly and injure it materially.

We have noticed ropes apparently sound outside that were all chewed in fine loose particles at the core, a circumstance we attribute to a use of too small pulleys.

It is usually necessary to use more than one rope to transmit the power; in such cases there may be a separate rope for each pair of grooves with a tightener to each rope, or one of the pulleys may have one more groove than the other from which the rope may pass to a secondary pulley, which acts as a tightener for the whole system, consisting of an endless rope in this case. Circumstances and locations govern the selection of either these methods.

Table, Price List and Horse Power of Manila Rope.

Diameter in inches	Weight Per Yard	Breaking Strain	Working Strain	Horse Power at 1000 feet per Minute	Price per Foot
½ in.	.28	2250 lbs.	112¼ lbs.	1.15	3½c
⅝	.48	4000	200	1.80	4
¾	.70	5000	250	2.3	5
⅞	.91	7500	375	3.0	6
1	1.25	9000	450	4.0	9
1¼	1.90	14000	700	6.3	14
1½	2.50	20250	1012	9.0	17
1¾	3.63	30250	1512	12.	24

Wood or iron grooved pulleys may be used, but we particularly prefer iron if there is any liability to moisture at the location. There is a special rope made for this purpose which has proved particularly satisfactory; it is made of long manila fibre, laid in tallow.

When the power is transmitted in a vertical line there must be some reduction from this table, as the weight of the rope in this instance does not assist in the pressure upon the lower pulley.

This must be compensated for by extra tension on the tightener, which means that there is more tension on the rope than for equal power carried horizontally, and, to work well, ropes must be larger, run faster, or have an increased number of strands. Great care should be exercised in designing long vertical drives.

WIRE ROPE TRANSMISSION.

Wire rope for transmitting power is practical and cheaper than shafting or belting, particularly if the location is exposed to the weather. The grooved wheels or sheaves on which the rope runs should be large in diameter (say 60 times the diameter of the rope), and the grooves should be lined with rubber or wood on end.

Rules to Determine the Size and Speed of Pulleys and Gears.

The driving pulley is called the "Driver," and the driven pulley the "Driven." If the number of teeth is used in gears instead of the diameter, merely substitute "number of teeth" where "diameter" occurs in following rules:

To find the diameter of Driver: Multiply the diameter of the "Driven" by its revolutions and divide the product by the revolutions of the "Driver." The quotient will give the diameter of the driver.

To find the diameter of Driven: Multiply the diameter of the driver by its revolutions, and divide the product by the revolutions of the "Driven." The quotient will give the diameter of the "Driven."

To find the revolutions of the "Driver": Multiply the diameter of the "Driven" by its revolutions, and divide the product by the diameter of the "Driver." The quotient will be the revolutions of the "Driver."

To find the revolutions of the Driven: Multiply the diameter of the "Driver" by its revolutions, and divide the product by the diameter of the "Driven." The quotient will be the revolutions of the "Driven."

MENSURATION

TO FIND circumference of a circle multiply diameter by 3.1416.

To find surface of a ball multiply square of diameter by .31416.

To find diameter of a circle multiply circumference by 3.1831.

To find side of an equal square multiply diameter of circle by .8862.

To find cubic inches in a ball multiply cube of diameter by .5236.

Doubling the diameter of a pipe increases its capacity four times.

A gallon of water (U. S. standard) weighs 8⅓ lbs. and contains 231 cubic inches.

A cubic foot of water contains 7½ gallons, 1728 cubic inches, and weighs 62½ lbs.

To find the pressure in pounds per square inch of a column of water, multiply the height of the column in feet by .434.

Steam rising from water at its boiling point (212 degrees) has a pressure equal to the atmosphere (1.47 pounds to the square inch.)

A standard horse-power: The evaporation of 30 lbs. of water per hour from a feed water temperature of 100° F. into steam at 70 lbs. gauge pressure.

To find capacity of tanks any size: given dimensions of a cylinder in inches, to find its capacity in U. S. gallons: square the diameter, multiply by the length and by .0034.

To ascertain heating surface in tubular boiler multiply ⅔ the circumference of the boiler by length of boiler in inches and add to it the area of all the tubes.

One-sixth of tensile strength of plate multiplied by thickness of plate and divided by one-half the diameter of boiler gives safe working pressure for tubular boilers. For marine boilers add 20 per cent. for drilled holes.

To find the amount of air that can be produced by different size air cylinders: Find the area of the cylinder and multiply that by the stroke; then multiply the result by 2 if it is a Straight Line Compressor; by 4 if a Duplex Compressor; or by 2 if a Compound Duplex Compressor. Divide this result by 1728, which will give the amount of air per stroke, and then multiply by the number of strokes per minute.

GENERAL INFORMATION AND METRIC CONVERSION TABLE.

B. T. U. (British Thermal Unit) = heat required to raise 1 pound of water 1 degree Fahrenheit (from 39.1 degree to 40.1 degree.)—Kent.

1 horse power = 43.78 B. T. U. = 746 Watts.

Calorie × 3.968 = B. T. U.
(Centigrade × 1.8) + 32 = Fahreheit.
Centimeters ÷ 2.54 = inches.
Centimeters × 0.3937 = inches.
Cubic centimeters ÷ 16.383 = cubic inches.
Cubic centimeters ÷ 3.69 = fluid drachms. (U. S. P.)
Cubic centimeters ÷ 29.57 = fluid ounces. (U. S. P.)
Cubic meters × 35.315 = cubic feet.
Cubic meters × 1.308 = cubic yards.
Cubic meters × 264.22 = gallons (231 cubic inches.
Cheval vapeur × 0.9863 = horse power.
Hectares × 2.471 = acres.
Hectoliters × 3.531 = cubic feet.
Hectoliters × 0.131 = cubic yards.
Hectoliters × 2.84 = bushels (2150.42 cubic inches.)
Hectoliters ÷ 26.42 = gallons. (231 cubic inches.)
Joule × 0.7373 = foot pounds.
Kilogrammes × 2.2046 = pounds.
Kilogrammes × 35.3 = ounce avoirdupois.
Kilogrammes ÷ 1102.3 = tons (2,000 pounds.)
Killogrammes per square centimeter × 14.223 = pounds per square in.
Kilogrammeters × 7.233 = foot pounds.
Kilogrammes per meter × 0.672 = pounds per square foot.
Kilogrammes per cubic meter = 0.062 = pounds per cubic foot.
Kilogrammes per cheval vapeur × 2.235 = pounds per horse power.
Kilowatts × 1.34 = horse power.
Kilometers × 0.621 = miles.
Kilometers ÷ 1.6093 = miles.
Kilometers × 3280.7 = feet.
Liters × 61.022 = cubic inches. (Act of Congress.)
Liters × 33.84 = fluid ounces. (U. S. P.)
Liters × 0.264 = gallons (231 cubic inches.)
Liters ÷ 3.78 = gallons (231 cubic inches.
Liters ÷ 28.316 = cubic feet.
Meters × 39.37 = inches. (Act of Congress.)
Meters × 3.281 = feet.
Meters × 1.094 = yards.
Square millimeters × 0.0155 = square inches.
Square millimeters ÷ 645.1 = square inches.
Square centimeters × 0.155 = square inches.
Square centimeters ÷ 6.451 = square inches.
Square meters × 10.764 = square feet.
Square kilometers × 247.1 = acres.
Watts ÷ 0.7373 = foot pounds per second.

POINTERS FOR MILLWRIGHTS

THE FIRST thing required in a first-class Mill is good motive power, and this you will find in a Modern I-X-L Steel Overshoot Water Wheel. Among all hydraulic motors none have as yet been discovered that give the satisfaction of the old faithful Overshoot, when properly constructed and put in, and in this all the ills and troubles have been overcome in the Modern I-X-L Steel Wheel. It is durable, and practically indestructible. The most important point is to look well to a foundation and water ways, and have them well constructed in all parts, remembering always to start right and end right.

In planning a mill, do it with as little machinery as possible to do a good job. Thousands of dollars are annually spent and wasted in superfluous machinery, all of which a good millwright would save. Have good proportions in gear and pulleys, always using gearing instead of belt for slow running shafts when possible. Avoid all unnecessary machinery that will waste power, and in all cases put in a Modern I-X-L Steel Overshoot Water Wheel. We will cheerfully give any information desired.

Our wheels are easily transported and simple to put up. We can send a man from the factory to put them up, or send instructions by which any good millwright can do it.

Look to the pulleys and see that they have been bored to the size of the shaft, for unless this is done the pulley may be out of centre on the shaft, and prevent smooth running.

If possible, apply the power to a line of shafting at or near the centre of its length, as it will enable you to use the lightest possible weight of shafting.

Hangers, with adjustable boxes, will be found to be the most convenient for keeping the shafting in line.

Keep your drip cups cleaned, and do not allow them to overflow or get loose.

Have a supply of tallow in the boxes ; in case of accidental heating it will melt and prevent cutting ; this rule, while good for general use, applies particularly to special cases where there is a supposed liability to heating.

Never lay tools or other things on belts that are standing still, for they may be forgotten and cause a breakdown when the machinery is started.

Don't attempt to run a shaft in a box that is too large or too small, as you will waste time and fail to secure good results.

A loose collar held by a set screw will cause the collar to stand askew, and it will cut and wear the box against which it runs.

In erecting a line of shafting, the largest sections should be placed at the point where the power is applied. The diameter can then be gradually decreased toward the extremities remote from this point.

Don't put loose bolts in plate couplings, as this will give no end of trouble in cutting, shearing and the wearing of the bolt holes.

Don't think that because your shafting has been well erected and you oil it regularly, that it will never need inspection or repairs.

Don't try to economize in first cost by having long distances between hangers, for a well supported shaft will always do the best work; short shafts are the surest to be straight and remain so.

The length usually adopted for shafting bearings is twice to four times the diameter of the shaft, varying with the characters of shaft, kind of bearings and the material used in them. Large shafts in the gun metal or gun boxes may have bearings only twice their diameter in length. Cast iron bearings up to and including three inch shafts are often made four diameters of the shaft in length, particularly for self-adjusting hangers.

If babbit is used for the boxes, use only a good metal; do not adopt the common mixture of tin, antimony and lead.

If the strain on a pulley is so great that the set screws already in will not hold it, do not let them score into the shaft, but put in an extra screw, or cut a key-way and put in a key.

The width of a key-way should be one-quarter of an inch for each inch diameter of the shaft.

The depth of a key-way is one-half its width.

Don't buy light hangers and think that they will do well enough, when your own judgment tells you that they will spring.

Remember that shafting is turned one-sixteenth inch smaller than the nominal size.

Cold-rolled and hot-rolled shafting can be obtained the full size.

The sizes of shafting vary by quarter inches up to three and a half inches.

The ordinary run of shafting is not manufactured longer than from 18 to 20 feet.

For line shafts, never use any that is smaller than one and eleven-sixteenth inches in diameter, as the smallest diameters are not strong enough to withstand the strain of the belts without springing.

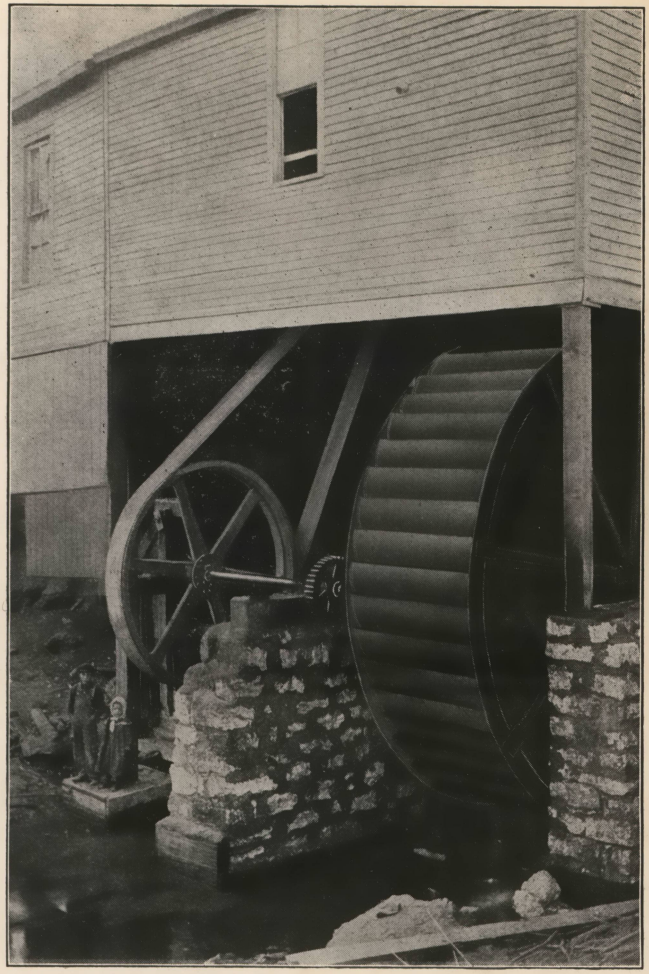
The economical speed of shafting for machine shops has been found to be from 125 to 150 revolutions per minute, and for wood-working shops from 200 to 300 revolutions.

CAST IRON PIPE—WEIGHT PER LINEAL FOOT.

Bore in Inches	Thickness of Metal in Inches.								
	¼	⅜	½	⅝	¾	⅞	1	1⅛	1¼
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
2	5.5	8.7	12.3	16.1	20 3	24.7	29.5	34.5	39.9
2½	6.8	10.6	14.7	19.2	24.0	29 0	34.4	40.0	46.0
3	7.9	12 4	17.2	22.2	27.6	32 3	39.3	45.6	52.2
3½	9.2	14 3	19.6	25.3	31.3	37.6	44.2	51.0	58 3
4	10.4	16.1	22.1	28.4	35.0	41 9	49.1	56.6	64 4
4½	11.7	18.0	24.5	31.5	38.7	46.2	54.0	62.1	70.6
5	12.9	19.8	27.0	34.5	42.3	50.5	59.9	67.7	76 7
5½	14.1	21 6	29.5	37.6	46.0	54.8	63 8	73.2	82 9
6	15 3	23 5	31.9	40.7	49.7	59.1	68.7	78.7	89 0
7	17 8	27 2	36.9	46.8	57.1	67.7	78.5	89.8	101.
8	20.3	30.8	41.7	52.9	64.4	76.2	88.4	101.	114.
9	22 7	34.5	46.6	59.1	71.8	84.8	98.2	112.	126.
10	25.2	38.2	51.5	65.2	79.2	93.4	108.	123.	138.
11	27.6	41.9	56.5	71.3	86.5	102.	118.	134.	150.
12	30.1	45.6	61.4	77.5	93.9	111.	128.	145.	163.
13	32.5	49 2	66.3	83.6	101.	119.	138.	156.	175.
14	35.0	52.9	71.2	89.7	109.	128.	147.	167.	187.
15	37.4	56 6	76.1	95.9	116.	136.	157.	178.	199.
16	39 1	60.3	81.0	102.	123.	145.	167.	189.	212.
18	44 8	67.7	90.9	114.	138.	162.	187.	211.	236.
20	49.7	75 2	101.	127.	153.	179.	206.	233.	261.
22	54.6	82 6	111.	139.	168.	197.	126.	255.	285.
24	59.6	89.9	120.	151.	182.	214.	245.	278.	310.
26	64.5	97.3	131.	164.	198.	231.	266.	300.	335.
28	69 4	105.	140.	176.	212.	249	286.	323.	360.
30	74.2	112.	50.	188.	227.	266.	305.	345.	384.

NOTE—For each joint add a foot to length of pipe.

8 ft. dia. by 4½ ft. face I-X-L Wheel in process of erection at mill of J. L. VanHeerden, near Zeerust, Western Transvaal, South Africa.



16 FT. DIAM. BY 5 FT. FACE I-X-L STEEL OVERSHOOT WATER WHEEL DRIVING FLOUR MILL AT BEAVER CITY, NEB.

WEIGHT AND SPECIFIC GRAVITY OF VARIOUS MATERIALS.

NAME.	Weight in Pounds		Specific Gravity.
	Pr. Cu. Ft.	Pr. Cu. In.	
Water, Pure, 60° F.	62 3	.036	1.00
Water, Sea	64.3	.037	1.03
METALS.			
Iron, Cast	450	.260	7.20
Iron, Wrought	480	.277	7.69
Steel	490	.283	7.84
WOODS.			
Cedar	35	.020	0.55
Cherry	42	.024	0.67
Chestnut	41	.023	0.66
Hemlock	25	.015	0.40
Maple	49	028	0.78
Oak, White	50	.030	0.80
Oak, Red	45	.026	0 73
Pine, White	30	.017	0.48
Pine, Yellow	35	.019	0.56
Walnut	41	.023	0.65

IMPORTANT.

In order to make an intelligent estimate on what you need, we must know something about the situation where the wheel is to go.

When writing for prices, please give us if possible, the number of cubic feet of water per minute that your stream will flow at ordinary times, measured by one of the methods described in this booklet. If not convenient to do this, let us know what size and make of wheel you are now using and how much work you can now do with it.

Also give the total fall you have from the top of the head water in the forebay to the surface of the standing water in the tail race.

Give speed of line shaft, etc., to be driven by the wheel.

Tell us how your present wheel is geared to run your machinery, and if you can do so, send us a rough sketch of the same.

State whether you are troubled by back water and give any other information you think may have some bearing on the situation.

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